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CONTENTS.

EDITORIAL 121
The Problem of the Combustion of Atmospheric Nitrogen..... 121
An Interesting New By-Product Development..... 122
Sliding Scale Purchases of Zinc Ore..... 123
The Present Scarcity of Lead Ore..... 123
Ithaca Meeting of the American Electrochemical Society..... 124
Iron Reduction at the "Soo" by the Héroult Electric Furnace Process 124
Recent Developments in the Production of Nitrates from Air..... 126
In Memoriam—Eugene R. White. By F. A. J. FitzGerald..... 127
New York Section, American Electrochemical Society..... 128
CORRESPONDENCE:
Metallurgy of Zinc. By Woolsey McA. Johnson..... 128
Manufacture of Ferro-Nickel. By Ernst A. Sjöstedt..... 128
Metallurgical Calculations: Balance Sheet of the Blast Furnace. By J. W. Richards..... 129
The Use of Electrolytic Hypochlorite as a Sewage Sterilizing Agent in the United Kingdom. By John B. C. Kershaw..... 133
Fixation of Atmospheric Nitrogen. By Phillipe A. Guye..... 136
Containers for Alkaline and Lead Accumulators. By M. U. Schoop and C. Liagre 139
The Eldred Flame. By K. P. McElroy..... 141
Factory Scale Experiments with Fused Electrolyte—I. By Edgar A. Ashcroft 143
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN. 146
SYNOPSIS OF PERIODICAL LITERATURE..... 148
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS..... 151
RECENT METALLURGICAL PATENTS..... 153
BOOK REVIEW:
Cyanide Industry, Theoretically and Practically Considered.... 154
New Works of the Traylor Manufacturing & Construction Company. 155
Suction Gas Producers. By Oskar Nagel..... 157
Apparatus for Lifting Solutions by Compressed Air..... 157
Blowing Engines 158
NOTES 159
PERSONAL 162
DIGEST OF UNITED STATES PATENTS. Prior to July, 1902..... 162

The Problem of the Combustion of Atmospheric Nitrogen.

For the undisturbed maintenance of our civilization nothing is more important than continuity. The supply of the raw material for the work of to-morrow is one of the foremost problems of to-day, and among the most pressing problems which now confront mankind is that of opening new sources of supply of fixed nitrogen—undispensable alike in peace and in war—in the industries of fertilizers and of explosives. What the fertilizer industry means to our civilization may be judged from the fact that the production of fertilizers in the United States alone has increased during the last ten years from 2,000,000 tons to over 3,000,000—and this with our abundance of virgin soil. Our chief source of ammonia is now from the destructive distillation of coal, and the supply is steadily increasing with the introduction of by-product coke ovens, though the whole production in this country is not more than 40,000 tons a year, according to the latest statistics. On the other hand, the supply of Chili saltpeter is bound to run out within the next twenty or thirty years. It is, therefore, not only a problem promising large returns to the successful inventor—no, it is a moral obligation to future generations, to render available in useful form the practically unlimited quantities of elementary nitrogen in the atmosphere. As important as the bound nitrogen is in many industries, so useless is it in the elementary state *per se*. Which, then, are the possibilities of fixing the atmospheric nitrogen in useful compounds?

* * *

If we observe how nature forms nitrogen compounds, we may study the work done by certain kinds of bacteria which bind the atmospheric nitrogen by some secret of their own. This voluntary process of Nature was made use of some hundred years ago in various European countries for agricultural purposes, but has been abandoned on account of the expense, and is now almost forgotten. More recently the United States Department of Agriculture has made interesting experiments on the artificial inoculation of the soil with cultures of these forms of bacteria. It would be most interesting to know exactly what happens. According to A. Fischer, it seems that the energy required for the formation of the nitrogen compounds is furnished by fermenting organic substances; the hydrogen given off combines with the nitrogen and the first assimilation product is presumably ammonia. Besides this process, which is at present only of biological interest, there are a number of chemical methods available.

* * *

First, it is a fact that under certain conditions oxidation of nitrogen will occur even at low temperatures, if simultaneously another substance is oxidized. An example is the observation which Schoenbein made in 1861—namely, that nitric acid is formed when phosphorus oxidizes in humid air. Schoenbein, in describing this fact, referred to the older observations of

Priestley and Cavendish on the effect of an arc discharge through air, and expressed frankly his inability to explain the peculiar ("merkwürdig") process of nitric acid formation; "our explanations leave much to be desired." With respect to the phenomenon described by Schoenbein we are not much further at the present day, though we now classify it under a general class for which we have a pretty name—antoxidation. A second possibility of fixing atmospheric nitrogen could be derived from the phenomenon that nitrogen combines comparatively easily with some "non-noble" metals, like lithium, forming a nitride, according to the equation $3Li + N = Li_3N$. By treating the nitride with water it would then be possible to get ammonia with a simultaneous formation of lithium hydroxide. To base a practical process thereon, it would be necessary to regenerate metallic lithium, which could be done by electrolysis. This method has recently been the subject of some remarks by J. Brode, who thinks, however, that the process would be far too complicated and expensive for industrial operation. The problem to prepare ammonia synthetically from the elements is very attractive. It has recently been studied in detail by F. Haber. The formation of 1-gram molecule of ammonia at ordinary temperature and at constant pressure sets 12,000 calories free. But the reaction velocity is so very slow that for practical purposes it may be considered zero. If it was possible to find a suitable catalytic agent which would accelerate the reaction, the outlook would be very good. But the best catalyzer known at present —iron—is so inefficient as to make the process practically impossible.

* * *

There remain two processes which are most interesting, since they now are becoming of commercial importance. First, the fixation of atmospheric nitrogen in form of cyanamide, and, second, the direct combustion of atmospheric nitrogen by the electric arc discharge. We hope much of interest will be found in the two articles in our present issue dealing with these subjects, not only on account of the report of progress made on a commercial scale, but also in view of Prof. Guye's excellent summary of the application of modern principles of physical chemistry to the combustion of nitrogen. A number of investigators have contributed to the evolution of this theory, the fundamental hypothesis of which is extremely simple. It is, in fact, negative rather than positive, and states that there is no specifically electric effect whatever of the arc discharge on the combination of the nitrogen and oxygen. If the atmospheric pressure is constant, it is simply a question of the proper temperature, and the electric arc discharge is nothing but the most suitable means for producing a high temperature within the gas mixture and for allowing at the same time the gas mixture to be cooled very quickly afterwards, so as to prevent the reversal of the reaction. Another method of obtaining the same result is by means of explosions of mixtures of hydrogen and oxygen gases with additions of atmospheric air; as a matter of fact, Bunsen's old experimental researches in this field have recently been made use of by Nernst in calculations concerning the combustion of atmospheric nitrogen. In this connection we may mention that it is now usual to classify very different things under the name of chemical effects of electric discharges. By electric discharges through air we can produce ozone or nitric acid, but the production of ozone requires the silent discharge, and the production of nitric acid requires the arc discharge. In the latter case we may be reasonably sure that the effect is purely thermal. In the production of ozone we may have really an electric effect of the silent discharge, but it is also quite possible that the ozone is produced by the ultraviolet light which accompanies the discharge.

* * *

With respect to the commercial production of nitric acid from air by electric discharges, we have to distinguish two stages: first, the production of a mixture of gases containing small quantities of oxides of nitrogen, and, second, the transformation of this gas mixture into nitric acid of merchantable strength or into nitrates. It has repeatedly been pointed out that the cost of the second stage will be quite high, but no definite figures are available. For the first stage of the process we have as raw material air, which costs nothing, and the whole cost of this first stage of the process consists of capital charges and cost of power and attendance. It is evident that in this case the cost of power is of fundamental importance, and in considering the commercial success of the Norwegian Co. great stress must be laid on the very low cost of power at the plant—which is three or four times less than at Niagara. The problem is so important that the success obtained in Norway should encourage American enterprise again in this field, although most careful procedure is to be recommended.

An Interesting New By-Product Development.

We have often noticed in our editorial columns interesting phases in the evolution and in the diversification of industry in the United States. A notable difference between this country and our great industrial rival, Germany, is that we pay usually much attention to labor-saving devices to meet American high-wage conditions, but that Germany pays more attention to working up by-products to meet its high price of raw materials. Necessity has been the mother of invention in each case. And the remarkable result has occurred that hard endeavor has reduced the labor charge per ton product in the United States often to a figure lower than in Germany. Likewise, profit from by-products in Germany sometimes pays the entire cost of raw materials. A seeming hardship has thus been the spur to success. An example of this Teutonic line of progress, worked to a conclusion here in the land of "unlimited possibilities," is the recent installation of a 600-ton acid plant at Ducktown, Tenn., by the Tennessee Copper Co. This concern is working a large low-grade cupriferous pyrrhotite deposit by means of monster copper blast furnaces. The smelting is now real pyritic smelting, for less than 1.5 per cent of coke is used in the charge. The gases from the copper furnace are exceedingly rich in sulphur dioxide—6 or 7 per cent is an average figure. Moreover, the long column of charge acts like a return filter, and cleans the gas of all dust, though a dust collector has been provided for reasons of conservatism.

* * *

The utilization of the sulphur from copper ores for the production of sulphuric acid has long been used by the Nichols Chemical Co. at Laurel Hill, and from zinc ores by three zinc

works in the West. But the interesting feature of the Tennessee proposition is that the gas comes not from a roasting furnace but from a copper blast furnace. The high grade of gas made in pyritic smelting, of course, increases the capacity of the acid plant, for the "reaction velocity" of sulphuric acid-making is a maximum at about 7 per cent. Irregularities in the composition of the gas will be averaged by use of several furnaces, just as is the case in utilization of blast-furnace gas in gas engines. Another favorable fact, is the large acid market existing in the South in the phosphate fertilizer trade. The probable developments in sheet steel and wire making in Birmingham, Ala., will be another favorable future outlet for acid. This whole Tennessee development is an extremely stimulating instance of American wide-awake enterprise, and new processes of this kind are sure to be profitable where once the difficulties incident to their evolution are "met, seen and conquered."

Sliding Scale Purchases of Zinc Ore.

Dr. Franz Meyer called attention in our last issue to the extremely unsatisfactory manner in which zinc ores are sold by the miner to the spelter works in the United States. While the lead smelting industry has had the advantage of purchases of ores on a sliding scale for years, the zinc industry has been subject to distressing fluctuations in the price of ore and metal, due to lack of proper understanding between the producer and consumer of ores. This had to effect the unpleasant result of mutual suspicion and distrust between the producer and consumer of zinc ores. Such a state of affairs is unfair to both parties, and does not improve the conditions of the zinc industry in the United States. Such a remedy as Dr. Meyer has proposed is entirely in line with modern business methods and should be adopted as soon as possible. In any business at all, stability is required above all else. Indeed, the great and essential good of a "trust" is founded on the assurance of settled and permanent conditions. Improvement and advance is much more easily effected when it is known to a certainty that no great change will disturb economic conditions. The competition among the spelter workers for certain classes of ore, especially concentrates from the Joplin district, has reduced the margin of profit to a small figure, too small to be regarded as a legitimate return on capital invested in the reduction works. Such a condition is unhealthy. In the broadest sense, the interests of the mine owner and spelter company are identical, and no business can exist on a satisfactory basis if a policy of "dog-eat-dog" is pursued. If the time, worry and care expended by the management of the several zinc companies on ore purchases were expended in improvements in the plants and process, and in developing new markets for the metal and enlarging the known markets, the ultimate effect would redound greatly to the welfare of the entire industry.

* * *

A policy of settlements on zinc contents, less a certain loss of metal in the process, with a further deduction for "treatment charge," the average spelter quotation being the base, of course, for payment, has been employed for some time by the Belgian and German zinc companies. It has had exactly the result described in the previous paragraphs. The purchases of ore were made on a basis fair to both parties. The profit in the business was divided equitably. And as things go in this unsatisfactory world, both parties were satisfied with events. Nothing is truer than the statement that nowadays an enlightened self-interest produces superior results than does short-sighted selfishness. The policy of fair dealing applies universally and is retroactive. We believe that the future of the zinc industry in this country is in a measure dependent upon a mutual "get-together" attitude of all interested parties, and the adoption of the sliding scale for ore purchases, recommended by Dr. Meyer would be thus conductive to the best interests of all concerned.

The Present Scarcity of Lead Ore.

The rapid expansion of American industry in the past ten years has increased largely the consumption of all metals. This increase is figured at from 7 to 10 per cent yearly. As a consequence of such phenomenal growth, the miners of the country are called up for an enormous tonnage. In the lead business the result has been that the mines cannot meet the unprecedented demand, and naturally there has arisen a shortage of lead ores in the West and Mexico amounting to almost a famine. This condition has been clearly foreseen for some time by important interests in the metal business. As we mentioned in a recent editorial upon "copper as a collector for gold and silver," there has been apparent a decided tendency to abandon lead smelting for the recovery of the precious metals in favor of copper smelting.

* * *

As a general rule lead deposits do not extend to the depths to which copper deposits extend. There have been encountered at lower levels of Leadville, Park City and elsewhere low-grade deposits in which pyrites and blende predominate. The lead plant is thus forced to use a charge in which the lead content is continually growing smaller. And the consumer of lead is forced to pay a price for lead which is continually growing higher. Naturally, the use of zinc white as a substitute for white lead is increasing as also iron for lead pipe. Further, the advantage of the lead chamber sulphuric acid processes over the "contact" processes for 60° acid is lessening, owing to increased interest charges on lead tied up in the chambers. While all metal markets are evidencing this same pressure, in none is the question of the ore supply more serious and immediate than in the lead industry.

* * *

What will be the solution of the problem can only be stated in the most general terms. Of course, substitutes for lead will be used to a greater extent. In the future lead will thus show each year a gain in output not commensurate with the gain in other metals. More careful and closer work in ore dressing and lead smelting will increase the natural monopolistic value of the great lead mines of the United States and make valuable, deposits now of little worth. Energetic prospecting and exploration will develop new lead camps in America. And so natural causes will produce the proper remedy in the course of time. But at present it is a condition, not a theory, that presents itself to the lead smelter.

Ithaca Meeting of the American Electrochemical Society.

The ninth general meeting of the American Eelectrochemical Society will be held in Ithaca, N. Y., from May 1 to 3. The hotel headquarters will be at the Ithaca Hotel.

Ithaca may be reached either by the Lehigh Valley or the Lackawanna Railroads. Prof. L. M. Dennis is chairman, and Mr., R. C. Snowdon is secretary of the local committee, and will gladly furnish any information that members may desire.

The forenoons will be devoted to the reading and discussion of papers, the afternoons to visits and excursions.

On Tuesday afternoon the chemical laboratory, the dynamo laboratory and the engineering laboratories and shops will be inspected. In the evening of Tuesday, Prof. Wilder D. Bancroft will deliver his presidential address, and later there will be a smoker at the Town and Gown Club.

On Wednesday afternoon a visit will be paid to the filtration plant, the hydraulic laboratory, the power plant in the gorge and the Ithaca Gun Co. On Wednesday evening a subscription dinner will be served. On Thursday afternoon the works of the Remington Salt Co. will be visited, and perhaps those of the Morse Chain Works.

In the following we give a list of the papers which have been announced. Since the order in which the papers will be presented has not yet been arranged, the list is given in alphabetical order of the names of the authors:

Isaac Adams, "The Development of the Nickelplating Industry."

W. C. Arsem, "The Electric Vacuum Furnace."

W. D. Bancroft, "Lecture-Room Switchboard."

O. W. Brown, "The Reduction of Metal Sulphides."

C. F. Burgess and S. G. Engle, "Observations on the Corrosion of Iron Alloys."

C. F. Burgess and O. P. Watts, "A Microscopic Study of Electrodeposits."

F. K. Cameron, "The Movement of Suspended Clay and Other Similar Particles Under the Influence of the Current."

C. F. Carrier, Jr., "The Extraction of Sodium."

F. F. Colcord, "Impurities in Electrolytic Copper."

C. L. Collens, 2d, "Some Principles of Resistor Furnace Design."

B. E. Curry, "Electrolytic Corrosion of Copper-Tin Alloys."

B. E. Curry, "Electrodeposition of Bronze."

F. A. J. FitzGerald, "On the Density of Sodium Peroxide."

H. M. Goodwin and R. D. Mailey, "On the Physical Properties of Fused Magnesium Oxide."

H. M. Goodwin and H. A. Wentworth, "Electrometric Experiments with Reference to the Dissociation of Fused Salts."

G. A. Hulett, "Cadmium Standard Cell."

L. Kahlenberg and A. S. McDaniel, "Differences of Potential Between Manganese and Lead Peroxides and Various Aqueous and Non-Aqueous Solutions."

G. I. Kemmerer, "Cathodic Disintegration of Carbon in Electrolyte of Fused Chloride."

M. LeBlanc, "Electrolytic Chromium."

L. Lyndon, "Electrolyte Density in Storage Cells."

John Nelson, "The Effect of Oxides on the Adhesiveness of Electrodeposited Metals."

J. W. Richards, "Electrolysis of Caustic Soda."

E. S. Shepherd, "Errors in Pyrometry."

R. C. Snowdon, "Electrolytic Precipitation of Lead from Acetate Solutions."

E. A. Sperry, "Electrochemical Processes as Station Load Equalizers."

M. DeK. Thompson, Jr., "The Free Energy of Some Halogen and Oxygen Compounds Computed from the Results of Potential Measurement."

Maximilian Toch, "Electrolytic Corrosion of Structural Steel."

A. Van Winkle, "Electrogalvanizing."

R. von Foregger and F. G. Brindley, "Report on Experiments with Fused Sodium Peroxide in the Regeneration of Air in Submarines."

W. H. Walker, "An Instructive Laboratory Experiment in Applied Electrochemistry."

O. P. Watts, "A New Silicide of Molybdenum."

G. R. White, "Alternating-Current Electrolysis with Cadmium Electrodes."

G. R. White, "Ferromanganese Anodes in Caustic Potash."

G. R. White, "Laboratory Resistance Furnaces."

Iron Reduction at the "Soo" By the Heroult Electric Furnace Process.

On page 84 of our last issue we noticed briefly the telegram sent by Dr. E. Haanel to the Canadian Minister of the Interior concerning the full success obtained at Sault Ste Marie in the electric furnace trials of Dr. Paul Héroult.

Further information has become available through a lecture of Dr. Haanel, delivered before the Canadian Club in Toronto on March 12. In the audience were a great many Canadian business men, and the subject of Dr. Haanel's address was an explanation of the peculiar situation of Canada with respect to the manufacture of iron and steel and an exposition of the possibilities which the successful outcome of the tests of the Héroult process opens for Canada.

The distribution of the raw materials required for iron reduction in Canada is peculiar. The necessary coking coals for blast furnace work are found at the extreme East and West, while Ontario, Quebec, Saskatchewan and Alberta have large ore deposits but no coal; on the other hand, there are large water powers here available. This peculiar situation is favorable to an electric smelting process, since the electrical energy for heating the charge could be generated from water power, so as to make unnecessary the expense of fuel for heating purposes.

However, there would still be required carbon for reduction, and the question now arose whether the coke used in the blast furnace for this purpose could not be replaced in the electric furnace by charcoal, which could be made from mill refuse and other available sources of wood useless for other purposes, or by peat coke made from peat, of which there are abundant deposits in Ontario and Quebec.

Finally, the chief ores available in Canada are magnetite, and most of them carry such a high sulphur content as to be valueless for blast furnace smelting. The question was, if these magnetites could be treated successfully in the electric furnace with practical elimination of sulphur.

These were the principal questions which remained to be answered by practical tests, and they formed the programme of the tests at Sault Ste Marie.

It will be remembered that a few preliminary tests on the reduction of iron from ore in the electric furnace were made in France in 1904, and fully analyzed and discussed in the report of the Canadian Commission before which these tests were carried out. (See our Vol. II., p. 479.) From these tests the metallurgist of the Commission, Mr. Harbord, concluded that pig iron can be produced on a commercial scale at a price to compete with the blast furnace, only when electric energy is very cheap and fuel very dear; on the basis of the price of the electric horse-power-year at $10, and of coke at $7 per ton, the cost of pig iron production in the electric furnace is approximately the same as in a modern blast furnace. Dr. Haanel, the head of the Commission, already pointed out at that time that these results were obtained in experiments made off-hand, so to speak, in furnaces not at all designed for the reduction of iron ore, and that the results, therefore, indicated only the minimum that may be expected from the electric furnace.

It was for the purpose of giving the electric process a better chance of showing its possibilities, and for the further pur-

pose of solving the above-named special problems concerning high-sulphur ores and concerning the use of charcoal or peat coke, that the experimental plant was erected at Sault Ste Marie. The Lake Superior Power Co. offered a building in which to erect the plant, and the use of a 300-hp. generating set free of expense for four months. This offer was accepted.

The Canadian Government granted the amount of $15,000 for the tests.

Dr. Paul Héroult designed the plant, and the tests were carried out under his direction and responsibility. He was assisted by Mr. R. Turnbull and Mr. J. Sejournet. The Canadian Government was represented by Dr. Eugene Haanel, Dominion Superintendent of Mines. He was assisted by his son, Mr. B. Haanel, and by Mr. E. Nystrom.

The experiments with Canadian ores began in earnest the middle of February, the furnace being in operation night and day, with some intermissions, until March 5. During that time about 150 casts were made yielding 55 tons of pig iron. For the first experiments the ores employed were hematite, such as are used by the Algoma Steel Co. in their blast furnaces. For the remainder of the experiments different classes of Canadian magnetite, from the different sources of supply, all of high sulphur content, with the exception of Wilbur magnetite, which was low in sulphur, were employed. In Dr.



FIG. 1.—HEROULT PIG IRON FURNACE AT SAULT STE MARIE.

Haanel's address the chief results of the tests are summed up as follows:

Magnetite can be smelted just as well in the electric furnace as hematite, there being no difficulty of using ores of high sulphur content for the production of pig iron containing only a few thousandths of 1 per cent of sulphur, even when the slag was not particularly basic. The silicon content can be varied as required for the class of pig to be produced.

Charcoal and peat coke can be substituted for coke as the reducing agent without being briquetted with the ore. No difficulty whatever was experienced from this source.

In every instance the output was far greater, in several instances one-third greater, than the figures adopted by Mr. Harbord in the report of the Commission on electric smelting.

In continuation of work formerly done by Sjöstedt (our Vol. II., pp. 153, 188, 207; see also the letter by Mr. Sjöstedt on page 128 of this issue), Héroult succeeded in using roasted nickeliferous pyrrhotite for the production of a ferro-nickel pig of fine quality, and practically free from sulphur. The pyrrhotite contained about 1.6 per cent of sulphur, while the ferro-nickel pig produced contained 4½ per cent of nickel, and



FIG. 2.—PART OF THE PIG IRON PRODUCED IN ELECTRIC FURNACE.

was virtually free from sulphur. The estimated value of this product is $40.00 to $44.00 per ton.

Another improvement over former results, as stated by Harbord, relates to the consumption of the electrodes. This was small beyond expectation. When an electrode had been in use for three weeks, and during that time had been exposed to free air in an incandescent state for many hours, and had been used for melting down charges—which is always attended by a waste of electrode without a corresponding output of metal—even with this severe test the consumption per ton of pig iron produced was between 15 and 20 pounds of electrode. According to Dr. Héroult's estimate this item means an outlay of 30 cents per ton of pig iron.

From a commercial point of view it is important that poor ore is made valuable by the electric process. A blast furnace will not usually handle high sulphur ores, and requires, therefore, an ore which cannot be bought in Canada at a low figure. Dr. Haanel stated that he understands the Algoma Steel Works paid $3.75 for the hematite ore which they use in their furnace. Pig iron equal in value and lower in sulphur content can be made by the electric process from high sulphur ores, which can be bought for $1.25.

Pyrite cinders resulting from the roasting of pyrite in the manufacture of sulphuric acid, and which at present constitute a waste product, can be smelted into pig iron in the electric furnace. Titaniferous iron ores containing up to 5 per cent of titanium may also be treated successfully in the electric furnace. This latter fact is inferred from the successful treatment of ore containing up to 30 per cent titanic acid.

Dr. Haanel said that under the prevailing conditions in Canada it now only remains for the engineer to design a plant on a commercial scale of, say, 100 to 150 tons daily output, with all the necessary labor-saving appliances. Dr. Haanel concluded his address with the following appeal to the business men present: "The Government has furnished you with facts on which to base a sound judgment as to the feasibility of commercially engaging in the manufacture of pig iron by

the electric process; with that its duty to the nation is done, and it remains with you business men to apply, perfect and profit."

By the courtesy of Dr. Héroult we are enabled to reproduce two photographs which were taken at the Sault Ste Marie plant. Fig. 1 shows the 250-hp. electric furnace in operation. Fig. 2 shows a pile of pig iron produced, the gentleman standing on the right being Dr. Haanel.

We are obliged to Dr. Haanel for courteously placing at our disposal the photograph reproduced in Fig. 3, and showing the electric furnace with electric control apparatus and measuring instruments.

Dr. Haanel did not give in his lecture the exact figure for the consumption of electric power per ton of pig produced. Dr. Héroult states that an output of 12 tons of pig iron per



FIG. 3.—ELECTRIC FURNACE, TOGETHER WITH CONTROL APPARATUS AND MEASURING INSTRUMENTS.

day may be obtained with 1,000 electric horse-power. This means that 1 ton of 2,000 pounds requires some 83-hp. days (for comparison we may mention that in the report of the Commission two years ago Mr. Harbord stated it would not be safe to assume less than 0.350-hp.-year per ton of pig iron, which corresponds to 128-hp.-days per ton). Dr. Héroult emphasizes that this figure of 83-hp.-days per ton may be very much improved upon by the use of his method of changing all the carbon monoxide into carbon dioxide in the furnace itself. The object of this would be, of course, to utilize to the utmost the calories available in the fuel employed for reduction. Practical means for this purpose are described in a patent by Dr. Héroult, which has just been granted, and which will be found in this issue of our Analysis of Current Electrochemical Patents.

In this connection it should be stated here that in the main experiments at Sault Ste Marie no air blast was used to oxidize the remaining carbon monoxide. Two short tests which were made in this direction indicated a great improvement in the operation, but these tests were too short to derive from them exact figures. While using the term air blast in connection with the Héroult furnace, we may emphasize that the air blast has, of course, here, a function entirely different from the blast in the blast furnace.

The full detailed report on the tests which is now being prepared by Dr. Haanel will be awaited with great interest. But from the general results recorded above it is already evident that the outcome has been satisfactory far beyond conservative expectations, and Dr. Héroult, as well as the Canadian Government and Dr. Haanel, are to be heartily congratulated on the success of their enterprise.

Dr. Haanel's detailed report will be covered in these columns as soon as issued.

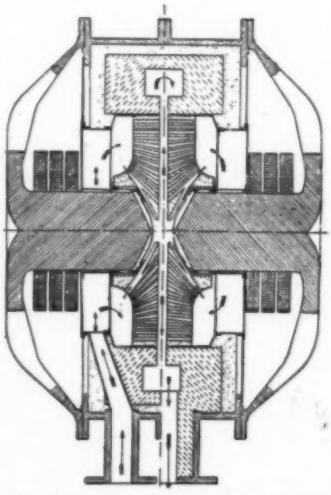
Recent Developments in the Production of Nitrates From Air.

Of the various processes for the fixation of atmospheric nitrogen in form of nitric acid or nitrates, the Bradley-Lovejoy process, which was in operation at the works of the Atmospheric Products Co., in Niagara Falls, was abandoned more than a year ago, as was noticed at the time in our columns. It is now stated that the Kowalski-Moscicki system (our Vol. I., p. 462, and Vol. II., p 152) which was tested on a large scale in Europe, has also been abandoned. The only survival of the processes which have passed through large-scale tests is that of Prof. Birkeland and Mr. Eyde in Kristiania, Norway, and this process appears to be in very good shape. Prof. O. N. Witt, in Berlin, and Prof. S. P. Thomson, in London, who visited the Norwegian plant as consulting experts, recently gave in lectures some new information.

The Birkeland-Eyde process was first brought before the public in a paper by Mr. J. S Edstrom before the St. Louis International Electrical Congress; this paper and further notes on the process may be found in our Vol. II., pp. 399 and 507, and Vol. III., p. 33.

The plant is located at Notodden on the shore of the Hitterdal Lake, whence there is water communication through a canal to Skien, and from there either to Kristiania or to Hamburg. The company also has a research laboratory at Vasmoen, near Arendal, which is stated to be magnificently equipped, and which has already undertaken the investigation of several other chemical processes of kindred nature.

The furnace is extremely simple. On each side of the "roaring disc of flame" there are fire-clay cheeks pierced with holes for the inlet of air, which is driven into the central region under a gentle pressure by a Roots blower, and passing radially arrives at a peripheral channel whence it is conducted away. The whole is enclosed in an external copper case, into which, on either side, there enter the poles of a large electromagnet. The horizontal electrodes are of copper. They approach one another to within about one-third inch, and are hollow, to permit of their being cooled by a water circulation that keeps them from fusing. They are not consumed, and need only to be replaced at intervals of a few weeks, when they have become slightly eroded or roughened on the surface.



ELECTRIC FURNACE FOR COMBUSTION OF ATMOSPHERIC NITROGEN.

The original form of the furnace was illustrated in Fig. 2, page 399, of our Vol. II. An improved form of the furnace is shown in the adjoining illustration. The nitric oxide fumes formed in the arc absorb oxygen from the unconsumed part of the air, and turn to nitric peroxide, which, when treated with water, combines to form nitric acid. But if the company had chosen to make nitric acid as final product for sale, its transportation to places of consumption would not have been an easy matter. The production of sodium nitrate by absorption of the nitric acid in caustic soda would have required importing caustic soda to Norway. On the other hand a very pure limestone is avail-

able in large quantities in the neighborhood. For this reason it was decided to produce calcium nitrate.

This "Norwegian saltpeter" has proved a valuable fertilizer, and is claimed to have a certain advantage over Chili saltpeter, owing to the nature of its basic constituent. When large quantities of sodium nitrate are employed for agricultural purposes it is frequently observed that the sodium acts prejudicially upon the vegetation; whereas, especially on soils poor in lime, the calcium nitrate is valuable both for its nitrogen and for the lime it introduces into the ground. Again, the synthetical calcium nitrate is necessarily free from all chlorine compounds, particularly perchlorates.

Calcium nitrate forms clear crystals containing four molecules of water of crystalization. By further treatment a nearly anhydrous nitrate of lime is obtained containing about 13 per cent of nitrogen. Thirdly, by the further addition of caustic lime a basic nitrate of lime is produced which is quite anhydrous. The manufacture of this basic nitrate was suggested by Dr. Rudolph Messel, of London.

At present nothing but calcium nitrate is made at Notodden, and the whole output can be disposed of easily. Great difficulties were first experienced in working up into acid of proper strength the very weak acid and highly diluted acid vapors issuing from the apparatus, but these difficulties are stated to have been completely overcome.

There are three furnaces of 500 kilowatts each. Air is supplied by blowers at about 50 liters per minute per kilowatt. The hot gases first pass through boilers where steam is raised, the steam afterwards serving to evaporate the nitrate liquors which are finally obtained. In a new plant which is being erected the hot gases are to be led directly through the evaporating pans, which change will effect a considerable economy. The cooled gases then enter two large oxidation towers, constructed of acid-resisting brick, and pass slowly through the same, emerging at a temperature of some 50° C. to enter the absorption towers, about 50 feet high, built of granite slabs and filled with lumps of quartz, over which water trickles.

The first tower yields a 50 per cent nitric acid, the second about 25 per cent, the third 15 per cent, the fourth 5 per cent. The liquids from the fourth tower are raised by compressed air to the top of the third, those from the third to the second, those from the second to the first, thus gradually increasing in concentration up to 50 per cent, at which density the acid is drawn off.

The gases then pass through a fifth tower in which they are treated with milk of caustic lime, and finally through a wooden tower over beds of dry quick lime. The 50 per cent acid is treated with limestone to form nitrate of lime, which is concentrated and poured molten into iron canisters ready for shipment.

The number of workmen is surprisingly small, most of the processes being automatic. One single assistant engineer attends the three furnaces; and his principal duty is to enter in the log-book every quarter-hour the readings of the electrical measuring instruments.

In his St. Louis Congress paper Mr. Edstrom stated that one kilowatt-year yielded 990 kg. of HNO_3, the electrical energy being measured at the arc. According to Prof. O. N. Witt the yield is between 500 and 600 kg. of anhydrous nitric acid per kilowatt-year, but not infrequently higher yields are obtained. It is not quite clear whether this reduction of the efficiency is an actual fact (due to a smaller efficiency on large scale than on an experimental scale), or whether it is only apparent, since the figure of Prof. Witt may give the kilowatt-hours consumed at the bus-bars instead of at the arc.

The water-power at Notodden was first developed for a pulp factory, and the engineering conditions were so favorable that the capital expenditure was under $27.50 per horse-power, and the cost of production only about 10 kronen per horse-power-year, which is about 0.04 cent per kilowatt-hour. The owners of the pulp factory sell part of their power to the saltpeter factory, at 23 kronen per horse-power-year, or at about $8.20 per kilowatt-year, or 0.094 cent per kilowatt-hour, yielding them a handsome profit.

Within a few months a new factory, more than double the size of the present one, will be erected alongside, and to meet its requirements another water-power in the neighborhood will be developed, and when delivered from the transmission line at the Notodden factory it is claimed that the cost of power will be less than $4.00 per horse-power-year. The projects of the company do not stop with the large factory at Notodden. Already powers have been acquired for the utilization of three other water-powers, one of 25,000 hp., a second one of 40,000 hp., and a third one still larger.

It is also reported that the Badische Anilin und Soda Fabrik, of Ludwigshafen, propose to lay down a water-power plant for the production of nitric acid by the Birkeland-Eyde process. However, instead of making calcium nitrate or sodium nitrate for artificial fertilizers, it is intended, in the first place, at least, to make potassium nitrate for explosive purposes.

In connection with these developments attention may be called to an excellent summary of the physical chemistry of the problem, which is given in an article by Prof. Guye, published elsewhere in this issue.

In Memoriam—Eugene R. White.

Eugene R. White, born in Buffalo July 19, 1872; graduated from Williams College in 1894; after leaving college he was engaged in newspaper work in Buffalo, and made some mark as a writer of prose and verse; in 1898 he became editor of the *Niagara Falls Gazette;* he died in Buffalo on March 16, 1906, after a short illness.

It is not necessary to dwell upon the loss of Eugene R. White as far as literature is concerned, for those who knew him and his purely literary work recognize fully not only the value of what he has done, but the promise there was of still better work in the future. But there is another aspect of the man which is likely to be overlooked, since from its very nature it could be known to but few.

There is a vulgar error, unfortunately very prevalent, that science and art are essentially antithetical. The blame for this lies partly with the man of science who will not take the pains to reveal his worth to the public, and partly with the literary man who generally is out of sympathy with scientific pursuits. Fortunately, there are exceptions to the rule, and a notable example was found in Mr. White. Till he came to Niagara Falls in 1898 his work had chiefly been of a literary nature; but here he found himself thrown into the society of men engaged in work of a scientific character. From that time on his interest in scientific subjects, and more especially in those of an electrochemical and electrometallurgical nature, continually increased. His broad sympathy with all forms of intellectual activity enabled him to appreciate at their value scientific pursuits. He quickly recognized the importance of public recognition to those engaged in research work, whether the object of such work was commercial or purely scientific, and he devoted much of his unusual ability as a writer to secure such recognition for those in need of it. Work of this kind demands an unselfish character, since the only reward the worker receives is the knowledge that he has done something towards the general progress of humanity Those outside of his most intimate friends know nothing of what he has done for others.

It was my privilege to be intimately acquainted with Mr. White from the time he first came to Niagara, and during that period I had abundant evidence of his ever present desire to assist the progress of science and industry. It is inevitable that little can ever be generally known of the help given by Mr. White in his own way to the progress of electrochemistry.

My last conversation with him was on the day before his fatal illness began, and we then discussed the question as to how he could be of assistance in the development of a recent advance in electrochemical work.

By Mr. White's death the electrochemical industries of Niagara Falls have lost a valued ally and those who knew him personally a friend ever ready with sympathy and encouragement. FRANCIS A. J. FITZGERALD.

New York Section American Electrochemical Society

By courtesy of the officials of Columbia University, a very enjoyable meeting of the New York Section of the American Electrochemical Society was held on March 22 in Havemeyer Hall.

Dr. Richard von Foregger presented a preliminary paper on the use of oxone for the purification and regeneration of air, and gave an account of a series of experiments made by him in conjunction with Mr. G. F. Brindley. These very interesting researches will form the subject of a paper at the Ithaca meeting, and will then be reported in our columns. An evident application of the method is, of course, for submarine boats, but the use of oxone was also suggested for purifying the atmosphere in the New York Subway.

Prof. Samuel A. Tucker explained the arrangement of the newly-equipped very fine electrochemical laboratories of Columbia University, which were then inspected. Refreshments were served afterwards. We hope to give a full description of these laboratories in a special article in a later issue.

CORRESPONDENCE.

Metallurgy of Zinc.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—The article by Dr. Franz Meyer in your last issue on the zinc industry in the year 1905 is extremely interesting and comprehensive. It, however, contains the incorrect statement that the American zinc metallurgists have learned how to treat ores containing as high as 20 per cent iron by the means of hydraulic-made retorts. The writer, over eighteen months ago, charged zinc ore averaging on an entire plant for some period over 22 per cent iron. The loss in zinc per ton of roasted ore was only some 10 pounds higher than the loss of zinc per ton of roasted ore in the furnaces operating on roasted concentrates from the Joplin field. The retorts used were the old-fashioned "tile-made" retort. This result was secured only by extreme care in roasting the ores, in blending them, in grinding the reduction material, in selecting the same and in blending ore and fuel carefully so as to produce a "non-corrosive" charge and one that would possess a higher reaction velocity.

The writer was not at all a pioneer in this line, but there are several other plants in the Kansas field who had made similar advances.

The writer does not wish at all to decry the merits of the Mehler hydraulic retort press. On the contrary, he is of the opinion that an installation of the Mehler press would pay for itself in from 90 to 120 days, due to increased recovery, from lessened zinc "soakage," from better condensation (due to the fact that the denser retort allows no filtration of the carbon dioxide, water-gas and oxygen inside the furnace to the retort with a diminished reductivity of the indifferent gases), and also from the fact that the scorifying material of the charge permeates to a less degree the cracks in the retort.

New York City. WOOLSEY MCA. JOHNSON.

Manufacture of Ferro-Nickel.

To the Editor of Electrochemical and Metallurgical Industry:

SIRS—I notice in your March issue of the INDUSTRY, page 105, that in Mr. Steinhart's paper at the January meeting of the Institution of Mining and Metallurgy, reference is made to the experiments made here some years ago in the production of ferro-nickel from roasted pyrrhotite in the electric furnace in the following terms:

"The Lake Superior Power Co., in 1902, attempted, in conjunction with E. A. Sjöstedt, to produce ferro-nickel in the electrical furnace from dead-roasted Canadian ores, but this process never came into practical use, although a large plant was put down."

The facts in regard to this matter were clearly put forth in my paper at the Fifth General Meeting of the American Electrochemical Society in 1904, from which I, therefore, beg to quote the following paragraph:

"Simultaneously with the above work (the electric smelting of a partially roasted pyrrhotite, containing about 3 per cent S), experiments in dead-roasting the pyrrhotite were also carried out, and these being sufficiently encouraging to warrant the belief that this could be done at small cost, while at the same time the resulting SO_2 gas could be profitably utilized in the sulphite pulp industry, and as the electric smelting plant on the large scale intended *would necessitate the completion of a large power plant*, it was decided to carry out the original intention of roasting the ore, briquetting the roasted fines, converting the briquettes into pig iron, and finally converting this pig metal by means of the open-hearth or Bessemer process into a ferro-nickel steel."

Thus it is made plain (1) that no electric installation for the manufacture of ferro-nickel was ever put down here; (2) that at no time was it our aim or intention to resort to electric furnace smelting for producing a ferro-nickel from a *dead-roasted* pyrrhotite, but from an incompletely roasted ore—a material so high in S as to make it unfit for the common blast furnace process

The successful roasting of pyrrhotites on the lines as above indicated, with the utilization of the SO_2 gas in the sulphite mill, was subsequently carried on here in a plant erected, capable of treating 40-50 tons of pyrrhotite per day, which plant was in continuous operation until, in 1903, the Consolidated Lake Superior Co. got into temporary financial trouble, when work was stopped; but as soon as the conditions of the new Lake Superior Corporation will permit, it is intended again to start these works, practically on the lines as at first suggested.

For the sake of furnishing a stronger SO_2 gas for the sulphite mill than what is possible when attempting to secure a dead-roast of the ore, our future practice would be not to aim at removing the S contents below 2 per cent, and to manufacture a ferro-nickel pig out of these "cinders" in the electric furnace.

The experiments lately carried out here by Dr. Héroult, under the supervision of the Canadian Government, have not only verified our previous results, but were made on a scale sufficiently large to encourage us to believe that, even in this small furnace, we will be able to profitably produce a ferro-nickel alloy on a semi-commercial scale, thus enabling us to follow up these researches under much more favorable auspices than previously.

I also wish to take exception to Mr. Steinhart's statement that "the companies 'La Société Electrometallurgique de Froges' and 'Le Ferro-Nickel' have produced ferro-nickel commercially," as I have been informed by parties lately connected with the first mentioned company that no such product has as yet been made by *them*, at least, on any commercial scale. ERNST A. SJÖSTEDT.

Chief Metallurgist, Lake Superior Corporation.

Sault Ste Marie, Ont.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

BALANCE SHEET OF THE BLAST FURNACE.

As the most important factor in the production of the most important metal, the blast furnace is the most important furnace or piece of metallurgical apparatus in the world. It is, therefore, proper that we should commence a series of articles on the application of metallurgical principles and calculations to the metallurgy of iron, by a discussion of the blast furnace; and since this discussion, to be complete, must include a wide range of topics, we will commence with the simplest, viz.: the balance sheet of materials entering and leaving the furnace. Later we can discuss the balance sheet of heat entering in, developed within and leaving the furnace, the reactions taking place in the furnace, the action of hot and of dried blast, the calculation of the proper constituents of the charge, the temperatures attained before the tuyeres, unused combustible energy of the gases, efficiency of the hot-blast stoves, and other interesting and practically valuable factors in the running of the furnace.

The blast furnace may be regarded from several points of view; we will mention two. First, it may be regarded as a huge gas producer, run by hot, forced blast, in which the incombustible portions of the contents are melted down (with a little unburnt carbon) to liquid metal and slag, and are run out beneath, while the gaseous products pass upwards through 50 to 100 feet of burden, and escape above. The escaping gases are primarily of the composition of producer gas, with some of its carbonous oxide changed to CO^2 by the oxygen abstracted from the burden, with some CO^2 added from the decomposition of the carbonates of the charge, and with the usual increment of moisture from the charge and volatile matter (if any) from the distillation of the fuel. From this point of view, the blast furnace is a huge gas producer, giving a rather inferior quality of combustible gas in very large quantities, and incidentally reducing to metal and slag the burden of iron ore and flux (limestone) which is put in with the fuel. The treatment of the furnace as a metallurgical problem may then proceed as the discussion of a gas producer, with the composition of the gas produced somewhat modified by the amount of oxygen given up to the gas by the reducible portions of the charge of the furnace.

The other viewpoint is to regard the furnace as primarily an apparatus for deoxidizing or reducing iron ore, for which purpose the ore is charged with sufficient carbonaceous fuel to do two things, viz.: to abstract all the oxygen from the reducible metallic oxides, and to furnish enough heat, or high enough temperature, to melt down to superheated liquids the pig iron and slag (combinations of irreducible metallic oxides) formed. In this view, the fuel must supply the reducing energy and the melting-down or smelting requirements; the first by acting upon the metallic oxides at a red to white heat, and abstracting their oxygen; the second, by being burned at the foot of the furnace by hot air blast, and there generating the heat and higher temperatures necessary for the smelting down of the already reduced materials.

Materials Charged and Discharged.

The materials put into a blast furnace may all be classed under four heads:

Fuel, Iron ore, Fluxes	Charged at the throat.
Blast	Blown in at the tuyeres.

The materials discharged from the furnace may be classed under four heads also:

Pig iron, Slag	Tapped from the crucible.
Gases, Dust	Passing out at the top.

We will discuss the resolution of each of the four materials charged into the four avenues of escape.

Fuel.

The fuel used is sometimes charcoal, but in the great majority of cases coke, with perhaps some raw bituminous coal or anthracite coal, or in a few cases all raw bituminous coal. The composition of these fuels consists of moisture, volatile matter, fixed carbon, sulphur and ash consisting of silica, lime, iron, alumina, alkalies, etc.

The moisture is driven off near the top, and goes into the gases as moisture. The volatile matter is expelled near to the top; almost all of it goes unchanged into the gases, but part of the hydrocarbons thus expelled may be decomposed and deposit fixed carbon on the iron oxides, etc., surrounding them. This carbon, however, will take up oxygen from the charge lower down in the furnace, and thus eventually pass into the gases as CO or CO^2. We can, therefore, assume without error that all the volatile constituents of the fuel pass into the gases, but cannot be certain in exactly what state of combination, except as regards the moisture. It will be quite exact if we know the ultimate composition of the volatile matters of the coal, as so much carbon, hydrogen, oxygen, nitrogen, sulphur, etc., to charge them thus entirely to the gases.

The fixed carbon all finds its way ultimately into the dust or the gases, either as CO, CO^2, CH^4 or HCN, or alkali cyanides, excepting the amount represented by the carbon in the pig iron. Subtracting the carbon in the pig iron from the total fixed carbon in the fuel, the difference can safely be put down as entering the gases or being in the dust carried away by the gases.

The sulphur in the fuel has a more varied history. When it is partly present in the form of iron pyrites, some may go into the gases as sulphur vapor, and eventually be burned to SO^2 when the gases are burned; another part may be oxidized in the furnace itself to SO^2, and as such appear in the gases; the rest, along with organic sulphur, passes either into the slag or the pig iron. Sulphur passing into the slag seems to do so as calcium sulphide, CaS, formed by some such reaction as

$$CaO + C + FeS = CaS + CO + Fe$$

or, if the sulphur was present in the fuel as gypsum,

$$CaSO^4 + 4C = CaS + 4CO$$

The amount of sulphur going into the iron depends really upon the opportunity for it to go into the slag. If the temperature of the furnace at the tuyeres is very high, and especially if the slag is low in silica, sulphur will keep out of the iron and go into the slag, to the extent of ten or twenty times as much being in the slag as in the iron; but if the temperature is low and the slag rich in silica the reverse may be the case. A high temperature and a high percentage of lime in the slag are the blast furnace manager's means of keeping down the sulphur in the iron, although high magnesia or high alumina are also efficacious. In casting up the balance sheet it can be assumed that when using coke or charcoal all the sulphur of the fuel goes either into the slag or the iron, and knowing from the analysis of the pig iron made how much goes into it, the rest can be calculated as going into the slag as CaS. If raw coal is used, it is uncertain how much sulphur goes into the gases, and an exact analysis of either the slag or gases, for sulphur, in addition to that of the pig iron, would be necessary to fix its distribution.

The ash of the fuel counts in with the other incombustible ingredients of the charge. Some of the silica in it may be reduced to silicon, and some of the CaO to Ca, to form CaS; while most of the iron will pass into the pig iron. It is in most cases uncertain whether the silicon in the pig iron comes at all from the fuel ash, so it is usual to assume it as coming from the silica of the ore only; as to the iron, it is best to

assume it all reduced to the metallic state, as is probably always the case.

Besides all these avenues of escape for the constituents of the fuel, it is sometimes necessary to take into account the possibility of some of it, in fine particles, being carried out of the furnace bodily with the outgoing gases. If the amount of this in the dust is determined, it must be subtracted *in toto* from the fuel charged, and then the remainder distributed as just discussed.

Illustration: A blast furnace is charged, per 1,000 kilos. of pig iron produced, with 925 kilos. of coke, containing by analysis: Fixed carbon, 86 per cent; volatile carbon, 2; hydrogen, 1; oxygen, 0.5; nitrogen, 0.5; sulphur, 1.0; iron, 2; silica, 5; lime, 1; moisture, 1. The pig iron contains 3.5 per cent of carbon and 0.1 per cent of sulphur. The dust carries 15 kilos. of dry coke per metric ton of pig iron. Required the distribution of the coke in the furnace per ton of pig iron made:

Charge		*Pig Iron*	*Slag*	*Gases*	*Dust*
Coke	925.0 kilos.				
Dust	15.0 "	....	....	....	Coke 15
Fixed C	782.6 "	C 35.0	....	C 747.6	....
Volatile C	18.2 "	....	....	C 18.2	....
H	9.1 "	....	....	H 9.1	....
O	4.5 "	....	....	O 4.5	....
N	4.5 "	....	....	N 4.5	....
S	9.1 "	S 1.0	S 8.1	....	....
Fe	18.2 "	Fe 18.2	....	....	....
SiO^2	45.5 "	....	SiO^2 45.5	....	....
CaO	9.1 "	....	CaO 9.1	....	....
H^2O	9.3 "	....	....	H^2O 9.3	....

ORE.

Whatever the varieties of ore used they can be averaged together, so as to get the average composition of the ore charged. Then, knowing its weight per unit of pig iron made, the distribution into pig iron, slag, gases and dust can be made.

There may, first of all, be blown out as ore dust up to 25 per cent of the ore charged. This must be first deducted as dry ore and then the rest distributed to pig iron, slag and gases.

The moisture of the ore, also any carbonic acid, may be considered as going over bodily into the gases. The sulphur may partly go into the gases if present as iron pyrites (this amount would have to be checked by an analysis of the gases for sulphur or hydrogen sulphide), but mostly into the slag as CaS. Some of it may be put down as going into the pig iron, if the sulphur in the fuel does not account for all that appears in the analysis of the iron. The iron oxides present must be assumed reduced to metallic iron sufficient to furnish the iron in the pig iron from its analysis; the excess, if any, is put down as going into the slag as FeO; all the oxygen given off (the difference between the weight of iron oxide in the ore and the sum of iron going in the pig iron and ferrous oxide passing in the slag) goes to the gases. If there is not enough iron in the ore to account for all in the pig iron, then none is assumed to go into the slag.

The manganese oxides in the ore furnish the manganese in the pig iron, the excess going into the slag as manganous oxide MnO, the oxygen (by difference) goes to the gases. The proportion of manganese reduced to metal increases with the temperature at which the furnace is run and as the slag is less siliceous. The amount reduced is known, however, only by the analysis of the pig iron.

Zinc in the ore is partly found as ZnO in the slag, and partly as flakes of white zinc oxide in the gases, which latter partly deposit in the dust catcher and are partly carried by the current of gases into the stoves and under the boilers. The relative amounts going into slag and gases can be best controlled by analysis of the slag.

Copper, silver, gold, nickel, cobalt, phosphorus, antimony and arsenic are almost completely reduced into the pig iron; careful analysis of the latter will show exactly to what extent, but without this careful analysis they may be assumed to pass completely into the iron. Lead is mostly carried out as fume, a small amount passes into the pig iron, and, if present in quantity, a large amount may collect as metallic lead beneath the pig iron and, if it can, soak into the foundations of the furnace.

Alumina usually passes completely, as such, into the slag. When present in large amount, producing a slag rich in alumina, and with very hot blast, the pig iron may contain as much as 1 per cent of aluminium, the oxygen thereof passing into the gases. Magnesia may be assumed as passing completely into the slag; none is reduced. Lime goes into the slag, except a not-unimportant quantity which is reduced by carbon in the presence of sulphur compounds, and forms CaS, its oxygen passing into the gases; a very small amount may go as calcium into the pig iron. Alkaline metals partly go into the slag, while some may pass into the gases as alkaline cyanides. Titanium oxide, tungsten oxide, chromium oxide and the oxides of molybdenum, uranium, vanadium are sometimes reduced in small amounts, the more the hotter the furnace is run and the more basic the slag, while the bulk of them passes into the slag as the lowest oxide which each is capable of forming.

Silica mostly goes into the slag as SiO^2, but a portion is always reduced to silicon in the pig iron. The amount reduced is greater the hotter the furnace is run, the more slowly it is run, and the more siliceous the slag. In some cases as much as one-quarter of all the silica going into a furnace is reduced to silicon. It is probably reduced only by carbon dissolved in iron at the lower part of the furnace. The oxygen of the silica reduced goes into the gases.

Illustration: 1956.8 kilograms of ore is charged into a furnace per metric ton of pig iron made. The ore analyzes: Fe^2O^3, 71.43 per cent; SiO^2, 14.24; CaO, 2.05; MgO, 1.51; MnO^2, 4.15; SO^3, 1.40; H^2O, 5.00; Cu^2O, 0.22 per cent. The pig iron contains 93.03 per cent iron, 3.27 carbon, 1.20 manganese, 0.08 sulphur, 0.40 copper, 2.02 silicon. Assume the dry ore dust to weigh 4 per cent of the weight of ore charged, and that there is no sulphur found in the gases, but all the sulphur in the pig iron comes from the fuel. Cast up the distribution of the ore:

Charge		*Pig Iron*	*Slag*	*Gases*	*Dust*
Ore	1956.8 kg.				
Dust	78.1 "	....	....	....	Ore 78.1
Fe^2O^3	1339.2 "	Fe 930.3	FeO 9.1	O 499.8	....
SiO^2	267.0 "	Si 20.2	SiO^2 223.6	O 22.2	....
MnO^2	77.8 "	Mn 12.0	MnO 48.0	O 17.8	....
Cu^2O	4.1 "	Cu 3.6	....	O 0.5	....
CaO	38.4 "	....	CaO 20.1 Ca 13.1	O 5.2	....
MgO	28.3 "	....	MgO 28.3	....	....
SO^3	26.3 "	....	S 10.5	O 15.8	....
H^2O	97.6 "	....	....	H^2O 97.6	....

In calculating the above we note that the dust is dry, and weighs 4 per cent of the ore, making 78.1 kilos. of dry dust, representing 82 kilos. of moist ore, leaving 1874.8 kilos. of moist ore to be distributed, plus the 3.9 kilos. of water from the dust, which also goes into the gases. This 1874.8 kilos. contains the weights given, calculating from its analysis. The 1339.2 kilos. of Fe^2O^3 contains 937.3 kilos. of iron; but there are only 930.3 kilos. in the ton of pig iron, therefore the other 7.0 kilos. must go into the slag as $7.0 \times \frac{72}{56} = 9.1$ kilos. of ferrous oxide, while $1339.2 - (930.3 + 9.1) = 499.8$, the weight of oxygen going into the gases. The 267.0 kilos. of silica contains 124.6 kilos. of silicon, but there are only 20.2 kilos. in the pig iron, therefore, 104.4 kilos. must remain unreduced, passing into the slag as $104.4 \times \frac{60}{28} = 223.6$ kilos. of silica, while $267 - (20.2 + 223.6) = 22.2$ kilos. of oxygen goes into the gases. Another, and equally logical procedure, is to start with the 20.2 kilos. of silicon in the pig iron, which must have required $20.2 \times \frac{60}{28} = 42.4$ kilos. of silica to furnish it, yielding $42.4 - 20.2 = 22.2$ kilos. of oxygen to the gases, and leaving $267.0 - 42.4 = 223.6$ kilos. of silica unreduced to go into the slag.

The 12.0 kilos. of manganese in the pig iron would be reduced from $12.0 \times \frac{87}{55} = 19.0$ kilos. of MnO^2, furnishing, therefore, 7.0 kilos. of oxygen to the gases, and leaving $77.8 - 19.0 = 58.8$ kilos. of MnO^2 to go into the slag as MnO. The molecular weights of MnO and MnO^2 being respectively 71 and 87, there is $58.8 \times \frac{71}{87} = 48.0$ kilos. of MnO going into the slag, while 10.8 kilos. more of oxygen will be supplied to the gases, making altogether $10.8 + 7 = 17.8$ kilos. of oxygen given up by the MnO^2. The 4.1 kilos. of Cu^2O contain 3.6 kilos. of copper, all of which enters the pig iron and contributing 0.5 kilos. of oxygen to the slag.

The 38.4 kilos. of CaO must supply enough Ca to form CaS with the S of the SO^2. The latter quantity is $26.3 \times \frac{32}{80} =$ 10.5 kilos., to supply which there is needed $10.5 \times \frac{40}{32} =$ 13.1 kilos. of calcium. The latter will be supplied by $13.1 \times \frac{56}{40} = 18.3$ kilos. of CaO, furnishing 5.2 kilos. of oxygen to the gases, and leaving $38.4 - 18.3 = 20.1$ kilos. of CaO unreduced to go into the slag. The MgO in the ore goes directly into the slag. The oxygen of the SO^2 goes into the gases. The 5 per cent of water of the whole quantity of ore charged goes into the gases as vapor.

FLUX.

The flux is used for the purpose of making a fusible slag with the slag-forming ingredients contributed by the ore and fuel. If we consider the distribution of ore and fuel given in the preceding illustrations we see that the chief material to be fluxed is silica, with smaller quantities of FeO, MnO, CaO, MgO and CaS. The cheapest and most available material to flux silica is limestone, the slag formed being a silicate of lime, magnesia and alumina, with CaS and smaller quantities of other basic oxides. We will not discuss at present the considerations governing the amount of flux used, since this is a calculation requiring separate treatment, as the proper working of the furnace depends fundamentally upon it. We may remark here that enough flux must be used to make an easily fusible fluid slag, rich enough in lime, magnesia or alumina to carry away satisfactorily the bulk of the sulphur, and so produce good pig iron.

The flux usually contains CaO, MgO, Al^2O^3, SiO^2, FeO, CO^2 and H^2O. Its H^2O and CO^2 are driven off in the upper third of the furnace, and may be put down as going as such into the gases. The FeO may be reduced if the slag is very clean, but under ordinary conditions may be put down as all going into the slag, unless in quite large amount, because the iron in ore and fuel usually supplies the total weight of iron in the pig iron. The silica and alumina may be carried over bodily into the slag. The magnesia can be put at once into the slag, but the lime cannot in many cases be treated that way, because quite frequently some is needed to supply calcium for the sulphur of the fuel. In the fuel previously illustrated, for instance, there is not enough CaO present to furnish Ca for the S, whence it follows that some CaO from the flux will be needed to make up the deficit. We may, in such a case, either consider all the CaO of the fuel to form CaS with part of the sulphur, and then take enough CaO from the flux to unite with the remainder. Or, it is equally permissible to take all the CaO necessary to furnish Ca to all the sulphur of the fuel, and to let the CaO of the fuel figure as passing entirely into the slag. The latter requires a little less calculation.

Illustration: A blast furnace receives 503 kilos. of limestone flux per metric ton of pig iron made, which analyses CaO, 29.68 per cent; MgO, 20.95; SiO^2, 3.07; Al^2O^3, 2.66; FeO, 0.48; CO^2, 42.66; H^2O, 0.50 per cent. Assume 8.1 kilos. of sulphur in the fuel, for which the flux must provide calcium. Required the distribution of the flux, assuming it to make no dust:

Charge		*Pig Iron*	*Slag*		*Gases*	
Flux	503.0 kg.					
CaO	149.3 "	....	Ca 10.1 CaO 135.1		O	4.1
MgO	105.4 "	....	MgO	105.4	....	
SiO^2	15.4 "	....	SiO^2	15.4	....	
Al^2O^3	13.4 "	....	Al^2O^3	13.4	....	
FeO	2.4 "	....	FeO	2.4	....	
CO^2	214.6 "	....	....		CO^2	214.6
H^2O	2.5 "	....	....		H^2O	2.5

The only calculation needed above is that 8.1 kilos. of sulphur require $8.1 \times \frac{40}{32} = 10.1$ kilos. of calcium, which would be furnished by $10.1 \times \frac{32}{40} = 14.2$ kilos. of lime, leaving 4.1 kilos. of oxygen to go into the gases and 135.1 of lime to go into the slag.

BLAST.

The remaining item needed to complete the balance sheet is the amount of blast. This may be roughly estimated by obtaining the piston displacement of the blowing engines, and assuming a coefficient of delivery into the furnace. This is very rough, because the efficiency is not known, and may vary anywhere between 0.5 and 0.95. Another rough approximation may be obtained by observing the pressure of the blast, its temperature, the back pressure in the furnace, and knowing the area of the tuyeres, and assuming a coefficient of contraction of the hot air jet as it emerges from the tuyeres. Here, again, are several uncertain factors, and the coefficient may vary between 0.9 and 0.98. Calculations on this basis are very rough.

The only satisfactory way to determine the blast is to carefully analyze the gases, determining carefully all the carbon, oxygen and nitrogen which they contain. Since the carbon comes only from the charges, the amount of gas produced per unit of pig iron made becomes known, and thence the oxygen and nitrogen contained in them. These, minus the oxygen and nitrogen coming from the solid charges, leave the oxygen and nitrogen which must have come from the blast. The oxygen in the blast, minus $\frac{3}{10}$ the nitrogen, gives the oxygen entering as water vapor; but this last calculation is not so satisfactory as to observe the atmospheric conditions, and calculate the air and moisture on the basis of the contained nitrogen.

The blast contains oxygen, nitrogen and moisture. All its constituents pass into the gases, being put down as so much oxygen, nitrogen and hydrogen. Just how much of that hydrogen gets into the gases as free hydrogen and how much as water vapor is not known. Argon and other rare gases in the blast are counted and treated as nitrogen. The carbonic acid of the air is present relatively in such a small amount that it can be neglected, as far as all ordinary calculations are concerned.

Problem 51.

A blast furnace at Herräng, Sweden, is run on ore briquettes made by pressing and calcining fine concentrates. The analyses of briquettes, charcoal and limestone flux are as follows (see Journal Iron and Steel Institute, I., 1904):

	Briquettes	*Limestone*	*Charcoal*	
Fe^2O^3	85.93	0.18		0.32
FeO	3.96	.....	C	80.31
SiO^2	5.50	3.14		0.19
MnO	0.63	.....	N	.08
Al^2O^3	0.76	0.32	O	3.54
CaO	2.23	53.74		0.89
MgO	0.97	0.17		0.10
P^2O^5	0.006	0.006		0.0068
S	0.010	0.001		0.0170
Cu	0.007	CO^2 42.42	H^2O	14.04
			K^2O	0.50

The pig iron contains phosphorus, 0.012 per cent; sulphur, 0.007; manganese, 0.025; silicon, 0.60; carbon, 2.70; iron, 96.656. There is used in charging the furnace:

Briquettes	1,190	pounds
Limestone	90	"
Charcoal	530	"

And the fuel consumption is 682 pounds of charcoal per 1,000 pounds of pig iron made.

The gases at the throat (dried) analyze: N^2, 57.3 per cent; CO, 23.1; CO^2, 14.8; H^2, 4.3; CH^4, 0.5 (Rinman). Assume blast dry. Dust in gases neglected. Required: (1) A balance sheet of materials entering and leaving the furnace, per 1,000 pounds of pig iron made. (2) The percentages of iron, manganese, silicon, sulphur and phosphorus going into the furnace, which go into the pig iron.

Solution: (1) Balance Sheet

Per 1000 of Pig Iron Made.

	Charges		*Pig Iron*		*Slag*		*Gases*	
Ore, 1630.2 lbs.	Fe^2O^3	1314.9	Fe	920.4	....		O	394.5
	FeO	60.6	Fe	46.2	FeO	1.2	O	13.2
	SiO^2	84.2	Si	6.0	SiO^2	69.6	O	8.6
	MnO	9.6	Mn	0.25	MnO	9.3	O	0.1
	Al^2O^3	11.6	....		Al^2O^3	11.6	....	
	CaO	34.1	....		CaO	34.0	O	0.03
	MgO	14.8	....		MgO	14.8	....	
	P^2O^5	0.092	P	0.04	....		O	0.05
	S	0.153	S	0.07	CaS	0.19	....	
	Cu	0.11	Cu	0.11	....		....	
Limest. 115.8 lbs.	Fe^2O^3	0.2	....		FeO	0.2	O	0.02
	SiO^2	3.6	....		SiO^2	3.6	....	
	Al^2O^3	0.4	....		Al^2O^3	0.4	....	
	CaO	62.2	....		CaO	62.2	O	0.00
	MgO	0.2	....		MgO	0.2	....	
	P^2O^5	0.007	P	0.003	....		O	0.00
	S	0.001	....		CaS	0.00	....	
	CO^2	49.1	....		....		CO^2	49.1
Charcoal, 682 lbs.	C	547.7	C	27.0	....		C	520.7
	N	0.5	....		....		N^2	0.5
	O	24.1	....		....		O	24.1
	Fe^2O^3	2.2	....		FeO	2.0	O	0.2
	SiO^2	1.3	....		SiO^2	1.3	....	
	CaO	6.1	....		CaO	5.9	O	0.06
	MgO	0.7	....		MgO	0.7	....	
	P^2O^5	0.046	P	0.020	....		O	0.03
	S	0.116	....		CaS	0.25	....	
	K^2O	3.4	....		K^2O	3.4	....	
	H^2O	95.8	....		....		H^2O	95.8
Blast	O^2	557.7	....		....		O	557.7
	N^2	1859.1	....		....		N^2	1859.1
	Totals	4,744.0		1,000.0		220.8		3,543.7

(2) The total iron in the charge is 969.2 kilos., while that in the pig iron is 966.6; the efficiency of the reduction of iron is therefore 99.7 per cent.

The total manganese in the charge is $9.6 \times \frac{55}{71} = 7.4$ kilos., of which only 0.25 gets into the pig iron, or 3.4 per cent.

The total silica charged is 89.1 kilos., representing 41.6 kilos. of silicon, of which 6.0 kilos. enters the pig iron, or 14.4 per cent.

The sulphur charged is 0.270 kilos., of which the pig iron contains 0.07, or 25.9 per cent.

The phosphorus charged is 0.063 kilos., while the analysis of the pig iron shows in it 0.12 kilos. It is thus evident that all the phosphorus goes into the pig iron; for while the analysis shows more phosphorus in the pig iron than was put into the furnace, yet the divergence is evidently due to segregation or concentration of phosphorus in the sample taken, and the practical conclusion is that all the phosphorus in the charge finds its way into the pig iron.

Notes on the Balance Sheet.

The Fe^2O^3 of the ore is assumed all reduced, because the 920.4 kilos. of iron in it is less than the 966.6 kilos. of iron known to be in the 1,000 kilos. of pig iron from its analysis. The FeO, however, cannot be assumed all reduced, because it would furnish 47.1 kilos. of iron, and there is only 966.6 — 920.4 = 46.2 kilos. of iron yet to be supplied. We, therefore, put down 46.2 kilos. of iron as going to the pig iron, thus furnishing all the iron in the pig iron, and leaving 0.9 kilos. of iron to go over into the slag as 1.2 kilos. of FeO. Having thus allowed for all the iron in the pig iron, the Fe^2O^3 in the limestone and fuel must be assumed as passing entirely into the slag as FeO.

The 6 kilos. of silicon in the pig iron is put down as coming entirely from the SiO^2 of the ore, of which 14.6 kilos. is thus used up, leaving 15.6 kilos. to go into the slag. The SiO^2 of flux and fuel must then be regarded as passing entirely into the slag.

The 0.25 of manganese in the pig iron comes from the MnO of the ore, requiring 0.35 of MnO, and leaving 9.3 of MnO to go into the slag.

The Al^2O^3 and MgO of ore, flux and fuel go bodily into the slag.

The sulphur in the ore, 0.153 kilos., is more than enough to supply the 0.07 kilos in the pig iron. We, therefore, put down 0.07 kilos. as going into the pig iron, supplying all the latter contains, and calculate the remaining 0.083 kilos. to CaS going into the slag. The CaO necessary to furnish this calcium is 56 for every 32 of sulphur (CaO = 56, S = 32), or 0.14 kilos., which, therefore, must be deducted from the 34.1 kilos. of CaO present in the ore. The oxygen of this 0.14 kilos. of CaO finds its way into the gases.

The 0.092 kilos. of P^2O^5 present in the ore contain only 0.04 kilos. of phosphorus, and since the pig iron contains, from its analysis, 0.12 kilos., we may assume all of this going into the pig iron. The same remarks are true of the P^2O^5 in flux and fuel; altogether, they come somewhat short of supplying all the phosphorus in the pig iron, and are, therefore, considered as completely reduced. The copper goes entirely into the pig iron, although not given in the analysis.

The Fe^2O^3 of the limestone must be transferred entirely as FeO to the slag, since all the iron needed for the pig iron has been already provided. The same is true of the Fe^2O^3 of the fuel; and an analogous statement applies to the SiO^2 and sulphur of both flux and fuel. The sulphur of the fuel does not produce an amount of CaS which counts in significant figures, and the CaO required is likewise insignificant, as is also the oxygen thus furnished the gases. In such cases, instead of ignoring the item altogether, or putting down wholly insignificant quantities, the amounts are expressed as 0.00, denoting no significant amount.

The fixed carbon of the fuel, only, furnishes the carbon in the pig iron, the rest going into the gases. The blast is calculated as follows:

Carbon in CO^2 of flux $= 49.1 \times \frac{12}{44}$	$= 13.39$ kilos.
Carbon in gases from fuel	$= 520.70$ "
Carbon in gases altogether	$= 534.09$ "
Carbon in 1 cu. meter of gas $(0.231 + 0.148 + 0.005) \times 0.54$	$= 0.20736$ "
Volume of gas per 1,000 of pig iron $= 534.09 \div 0.20736$	$= 2575.6$ m^3
Nitrogen in this gas $= 2575.6 \times 0.573$	$= 1475.9$ "
Weight of nitrogen $= 1475.9 \times 1.26$	$= 1859.6$ kilos.
Nitrogen from fuel	$= 0.5$ "
Nitrogen from blast	$= 1859.1$ "
Oxygen from blast $= 1859.1 \times 0.3$	$= 557.7$ "

Chemistry of Electric Incandescent Lamps.

Remarkable results are reported from Europe concerning the new Kuzel lamp (see, for instance, *Electrical World*, 1906, Vol. XLVII., pp. 354 and 487). It seems to bring into prominence a chapter of physical chemistry which was so far only of theoretical interest—namely, colloids. Kuzel brings metals and metalloids of high melting point into the colloidal state in water, where they become plastic without any binding material. They can then be easily moulded like clay, and when forced through a die and dried can be employed as filaments. Eutectic alloys are also used.

The Use of Electrolytic Hypochlorite as a Sewage Sterilizing Agent in the United Kingdom.

By John B. C. Kershaw, F. I. C.

Introduction.

The electrolysis of solutions of the alkali metal chlorides always produces chlorine at the anode, and the hydrate of the base (sodium, potassium or magnesium) at the cathode. In the electrolytic alkali processes, the aim of the inventor has been to effect removal of these products before they can react one with the other. In the electrolytic bleaching and disinfecting processes the chlorine and the caustic hydrate are allowed to react, in order that the chemical changes represented by the following equations may occur:

1. $3NaOH + 6Cl = 3NaOCl + 3HCl$, sodium hypochlorite and hydrochloric acid.

2. $3NaOH + 3HCl = 3NaCl + 3H_2O$, sodium chloride and water.

If the temperature be allowed to rise above a certain point a further chemical action will occur and chlorate will be produced. It is, therefore, necessary in all electrolytic bleaching and disinfecting processes to pay great attention to the temperature, as chlorates are useless for bleaching purposes.

The production of hypochlorite solutions for bleaching and disinfecting purposes by means of electrolysis has undergone little development in the United Kingdom, and only two types of cell are known to the writer to be at present in operation, namely: the Volgelsang and the Atkins cells.

Early in the nineties a considerable amount of money was expended, however, upon experimental trials with the Hermite cell for sewage purification and sterilization, and much attention was given to the results of these trials. The failure to establish this method of sewage treatment upon a commercially sound basis led to the bankruptcy of the firm financing these trials, and to a collapse of interest in all processes and cells for producing, by aid of electrolysis, a solution containing free chlorine for bleaching or disinfecting purposes. It is only lately that attention has again been given to this subject of sewage disinfecting and sterilization in the United Kingdom. The proposal of the medical officer of health for Poplar, to use electrolytic hypochlorite for disinfecting purposes within the Borough, has aroused considerable interest.

The low price at which hypochlorite of lime, or "bleach," is now selling in the United Kingdom (£4.10.0 per ton) is likely, however, to hamper the extension of these processes, for it is more than doubtful whether any of them can compete in price with the older bleaching agent. For certain purposes, hypochlorite of soda is much to be preferred to hypochlorite of lime, the active agent in bleaching powder; and in these cases the higher cost of the former, even when produced by the electrolysis of brine, is unlikely to retard its utilization as soon as a cheap, reilable and durable electrolytic cell for producing it is placed upon the market. The Hermite cell and process in its original form did not fulfil these conditions, and the same judgment must be passed upon many of the patented forms and processes which have succeeded it. Even with cheap power and a durable and reliable cell, electrolytic hypochlorite is unlikely to take the place of bleaching powder for ordinary bleaching purposes, until the price of the latter has advanced to over £6 per ton, and, therefore, the development of this industry is somewhat doubtful in countries where bleach is manufactured in large quantities, by either the old Le Blanc or newer electrolytic processes.

The following are details of the hypochlorite cells which have been patented and worked in the United Kingdom:

Charles Watt's Hypochlorite Cell.

The remarkable omnibus patent of Charles Watt (No. 13,755, of 1851) contains a reference to the method by which electrolysis may be applied to the formation of hypochlorites and chlorates in the following words:

"A warm solution, and nearly saturated, of the chloride of potassium or other chloride to be operated upon, is prepared and placed in a vessel furnished with two electrodes, and in Fig. 1 (Fig. 4 in the patent specification) I have shown a vessel furnished with a pair of electrodes, constructed in such a manner as to be convenient for carrying this part of my invention into effect.

"In this figure *B* is the interior of the vessel, which is furnished with a steam-jacket *A*, with connection to a boiler (*a*) and waste-steam tap *dg* thermometer; *EE* electrodes placed

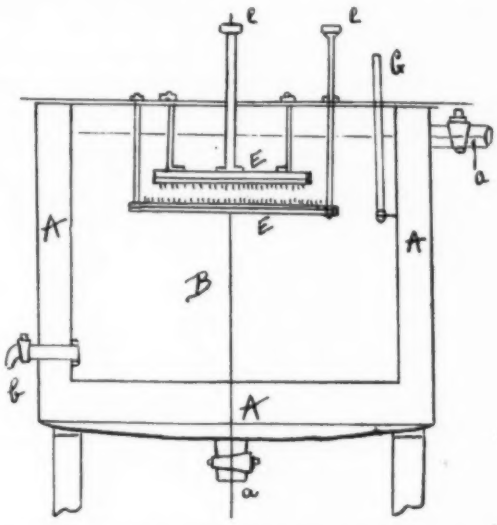


FIG. 1.—VERTICAL SECTION OF WATTS CHLORATE BELT.
(Reproduced from the patent.)

over each other, the lower one being intended for the elimination of the chlorine, and the upper one for the elimination of the alkali; *ee*, attachments of the electrodes. I have found it advantageous to add to the solution of the chloride a portion of free alkali or alkaline earth equal to about one-tenth of the quantity of the saline matter to be decomposed. The connection is now to be completed between the apparatus which supplies the electric current or currents and the vessel, and if the object be the formation of chlorate, I maintain the action until from one-half to two-thirds of the original saline matter shall be converted into a chlorate. The agency of the electricity first decomposes the chloride, the chlorine being eliminated at one of the electrodes, and the alkaline or earthy metallic base at the other electrode. The metal thus set free from its combination with chlorine combines with oxygen, and so becomes converted into an oxide, the oxygen being obtained from the water of the solution, a portion of which is therefore decomposed and hydrogen gas evolved; and this gas may be allowed to pass away or, if desired, collected in another vessel. The liberated chlorine will, when it is set free, combine with a portion of alkali or alkaline earth in solution, and a hypochlorite will be formed. The hypochlorite thus formed will, by the continued action of heat, be resolved partly into a chlorate of the alkali or earth and partly into a chloride of the metallic base; and the chloride will again be subjected to decomposition, and a hypochlorite formed in like manner as herein before described, and this action or succession of decompositions and changes will go on until I stop the process, which I prefer to do when from one-half to two-thirds of the saline matter has been converted or formed into the required chlorate. The quantity of chlorate thus obtained, or the greater portion of it being then separated by crystallization from the solution, the undecomposed saline matter remaining

in solution may, with an additional portion of the same saline matter, be subjected to the same process, for the convertion of a portion of it into a chlorate of the alkali or earth, as already described.

"If I desire to produce a hypochlorite of the alkali or earth, I merely keep the vessel warm (say from about 100° to 120° F. thermometer) without applying the higher temperature, which it is well known is requisite to produce a chlorate from a hypochlorite; and I continue the process until as much of the saline matter has been converted into a hypochlorite as may be required for the purpose to which the solution is to be applied. This mode of forming a hypochlorite of the alkalies and alkaline earth may be used for preparing a bath for the purpose of bleaching various kinds of goods, and the bath may be strengthened from time to time by the action of the electric current or currents."

The fourth section of Watt's 1851 patent relates to the use of electrolysis for separating and refining metals; but in the above extract Watt shows that he had a clear grasp of several of the important details, upon which the formation of hypochlorite and chlorate in the electrolytic cell depends.

Of course, at the date of Watt's patent no industrial application of this method of producing hypochlorite was possible, and it remained for Hermite to recall attention to the subject in the years 1884-1894.

The Hermite Hypochlorite Cell.

The Hermite cell contains a horizontal spindle, bearing a large number of discs made of zinc plates, capable of rapid rotation by means of a pulley wheel. These zinc discs are the cathodes of the cell, while an equal number of pieces of platinum gauze, fixed in lead or glass frames, hang between each of the consecutive pairs of zinc discs and act as anodes. The rotation of the spindle bearing the discs and the rapid circulation of the electrolyte cause a complete mixture of the solution, and little chlorine escapes as gas from the cell, the greater portion combining with the hydrate to form hypochlorite, in accordance with the chemical equation given above.

In Hermite's original patents a mixture of magnesium and sodium chloride solution was recommended as the electrolyte for use in this cell. The electrolytic decomposition led to the production of insoluble magnesium hydrate at the cathodes, and the zinc discs speedily became coated with a deposit of

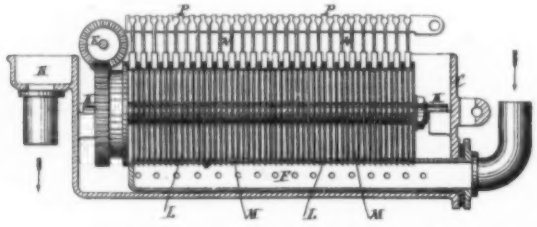


FIG. 2.—LONGITUDINAL SECTION OF HERMITE HYPOCHLORITE BELT.

this compound. Fixed scrapers did not satisfactorily remove it from their surfaces, and the EMF necessary to work the process was permanently increased, owing to the resistance offered by this film of hydrate on the zinc plates. The writer believes that on this account the procedure was altered, and that sodium chloride was used alone in preparing the electrolyte for the cells.

The Hermite cell, as described above, was tried at Worthing, Lytham, Ipswich and at Netley Hospital, Southampton, for sewage sterilization in the years 1890-1896. At Ipswich and the other places sea-water was used as electrolyte.

One of the forms of electrolyzer used (see Figs. 2 and 3) possessed a pair of horizontal spindles *KK*, each carrying a large number of the zinc discs *LLL*. The platinum gauze *MMM* was carried by a framework of glass rods. This form of electrolyzer produced 250 grms. chlorine, as hypochlorite, per hour. The electrodes were in parallel, and an EMF of about 6 volts was requisite to work the cell to the best advantage.

A modified form of the electrolyzer had been designed for the use of currents having a higher EMF than 6 volts. In this a number of the zinc and platinum pans were coupled in series. A full description of the apparatus will be found in British patent No. 6,497, of 1894.

The energy required to produce 1 kg. chlorine in the form of hypochlorite with this apparatus was given as .48-hp. day, or 11.4-hp. hours. At one-tenth of a penny per EHP hour, this represented a cost of 1.14d. = 2.28 cents per kg. of active chlorine. The solution obtained by the electrolysis of sea-water contained both sodium and magnesium hypochlorites. The latter quickly decomposed into magnesium hydrate and hypochlorous acid when mixed with the sewage effluent or when allowed to stand.

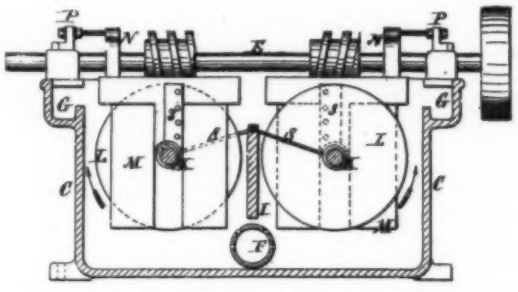


FIG. 3.—END SECTION OF HERMITE HYPOCHLORITE BELT.

This solution, according to M. Hermite, was a powerful deodorizer and an efficient sterilizing agent. The reports of the numerous experiments that had been carried out respecting its action on sewage were, however, very conflicting. With a clear effluent there appeared to be no doubt of its deodorizing and sterilizing properties when used in sufficient quantity; but upon solid foecal matter its effect was much less satisfactory. The most important independent criticism of the process, as applied to sewage, was made by Sir H. Roscoe and Mr. Lunt. They found that the weaker solutions of hypochlorite were exceedingly unstable, while the stronger solutions containing 1.0 gram active chlorine per liter, though much more stable, required a considerable loss of energy in the electrolyzer in order to obtain them. They, nevertheless, stated that the solution containing .25 gram active chlorine per liter was an excellent deodorizer.

The experiments made with the process at Ipswich in 1895 led Mr. Napier, the borough analyst, and Dr. Elliston, the medical officer, to report favorably upon the process as applied to the sewage of their town, the desire here being merely to arrest decomposition of the organic matters until the sewage had been carried out to sea.

The Ipswich plant, which cost $12,000, was started in May, 1895. A 30-hp. engine drove dynamos yielding 600 amps. at 28 volts; four electrolyzers, coupled in series, yielded 2.4 kgs. chlorine per hour. The electrolyzers were equal to providing 1 gram chlorine per head of the population per 24 hours, and the cost of running the installation was stated to be $1,680 per annum, or 3 cents per head per annum.

As regards the failure of the Hermite sewage disinfecting process, the following criticism, published by the present writer in 1898, is still of interest:

"As regards the use of the Hermite fluid for deodorizing sewage and for disinfecting purposes generally, the future is less certain. In many cases, where the sewage is turned directly into rivers or into the sea, there is at present no obligation to deodorize it, and the adoption of the Hermite treat-

ment would simply be resisted as an unnecessary expenditure. In cases where treatment of the sewage is absolutely essential the Hermite process fails, in that it is only successful when applied to the clear effluent, and the nuisance arising from the decomposition of the solid foecal matters is in no way abated. As an alternative procedure to the use of chloride of lime and carbolic acid, for the mere purpose of lessening the effluvia from the main sewers, it may find adoption; but it certainly cannot be regarded as the solution of what is still one of the

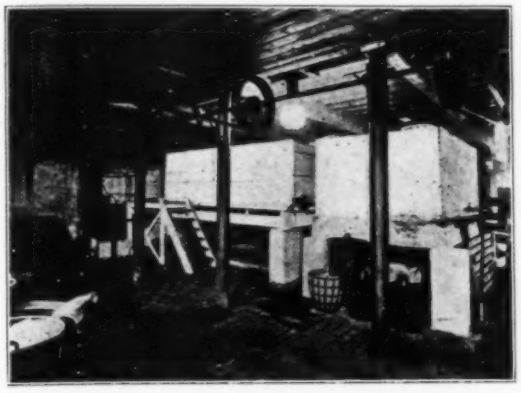


FIG. 4.—VOGELSANG HYPOCHLORITE CELL AT NOTTINGHAM.

greatest problems of the age—the production of innocuous and useful materials from the sewage of our great cities."

The Vogelsang Hypochlorite Cell.

The Vogelsang cell resembles in its main features the Hermite cell; but instead of working the intermediate electrodes of the cell in parallel, these are worked as secondary electrodes in series, and only the two end electrodes are connected to the terminals of the current conductors. These secondary electrodes are coated with platinum, in order to resist the action of the free chlorine and hypochlorite. By varying the number of intermediate electrodes a cell can be arranged to take a current of either 65 or 110 volts, and therefore can be adapted to the ordinary lighting supply of electricity.

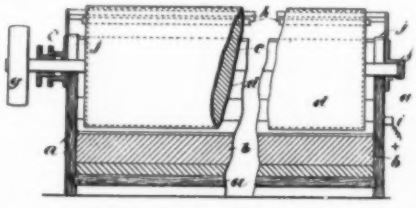


FIG. 5.—LONGITUDINAL SECTION OF ATKINS CELL.

An electrolytic cell of the Vogelsang type, taking 85 amps. and 115 volts, is said to produce bleaching liquor sufficient to bleach 4,000 pounds cotton yarn in a 10-hour working day. This weight requires 20 kgs. active chlorine, and the yield of the Vogelsang type of cell, *if the above figures can be relied upon*, is therefore 1 kg. active chlorine per 6.6-EHP hours, or an energy efficiency of 38.5 per cent.

The Vogelsang patents for electrical bleaching have been exploited in the United Kingdom by the Electrical Bleaching Co., of Nottingham, and a small experimental plant for demonstration purposes has been in operation in Nottingham since 1903. Fig. 4 is a view of this small plant, which is utilized chiefly for bleaching fine work and lace of Nottingham manufacture. In 1904, however, the exploiting company underwent financial reconstruction, and a new company, with headquarters in Manchester, and a capital of £75,000 was formed, to purchase the assets and to carry on the industrial development of this cell and process.

The Atkins Hypochlorite Cell.

This cell is covered by patent No. 5,596, of 1901, and it is being exploited in the United Kingdom by a company registered as "Oxychlorides, Limited," with a capital of £150,000 and offices in London.

The following is a description of the Atkins cell and process for producing hypochlorites. (See Figs. 5 and 6):

A wooden trough *a* of semi-circular cross-section forms the cell, and is lined first with lead and then with carbon blocks *b* shaped to fit the wooden vessel; these blocks form the anodes of the cell. A wooden cylinder *c*, also lead covered, revolves on bearings placed at the ends of this trough, and forms the cathode of the cell. A copper collecting ring *g* and brushes at one end of the bearings supply the electrical connection for this revolving cathode. The trough is filled with a 10 per cent solution of sodium chloride, and the electrolysis of this solution proceeds in the ½-inch space which separates anode and cathode. Figs. 5 and 6 show diagrammatic, longitudinal and cross-sections of the Atkins cell. The cell with which the preliminary experiments have been conducted is 10 feet in length, and the cathode cylinder is 2 feet in diameter.

A current of 1,500 amps. at 3.5 to 4 volts is used to operate this cell, and a current density of 50 amps. per square foot is reported to be obtained. This represents a cathodic area of 30 square feet for the submerged half of the cylinder.

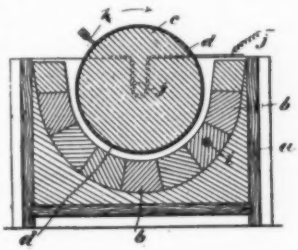


FIG. 6.—CROSS-SECTION OF ATKINS CELL.

The revolution of the cathode is designed to lessen polarization and reduction by the hydrogen liberated at the negative pole, and it is said to be effective in attaining this result. No figures are given for the electrical efficiency of the appartus, and in the absence of these it is impossible to compare its yield of available chlorine with that of other cells.

The Atkins cell has been worked upon a small scale for demonstration purposes at Forest Hill, near London, and towards the end of 1904 considerable attention was aroused by trials of the solution obtained from it for sewage sterilization purposes at Guildford, in Surrey. Three tanks were constructed at this place, each 50 feet long by 30 inches wide, with a total capacity of 4,000 gallons, and into these tanks the Guildford sewage, with the requisite amount of the hypochlorite solution, was pumped daily. Chemical and bacteriological tests were made, both with the untreated sewage and with the effluent from these tanks, on behalf of "Oxychlorites, Limited," by Dr. Rideal, of London, and the results obtained are held to be favorable to this method of sewage sterilization. An addition of 3¼ gallons of hypochlorite solution per 1000 gallons of sewage is stated to be sufficient to nearly exterminate all the more dangerous bacteria of the sewage, while with the effluent from septic tanks a greatly reduced proportion of the hypochlorite solution suffices to kill, or render innocuous, the pathogenic organisms. No details as to the cost of this method of treatment have, however, been published, and in the absence of these figures no judgment can be passed upon the future of the process. In the light of the previous failures with the Hermite process at Ipswich and other places, with the Wolf process at Maidenhead, and of similar processes in France and America, the future prospects of this application of electrolytic hypochlorite to sewage sterilization cannot be considered very hopeful.

The Woolf Hypochlorite Cell.

This cell, patented by an American engineer named Woolf,

was operated at Havana, in Cuba, at the close of the Spanish-American war, and was introduced into England by "The Electrozone Co.," in 1895, and an experimental plant for treatment of sewage with the solution produced was erected at Maidenhead in 1896.

As worked at Havana, the Woolf electrolyzer consisted of a large circular wooden vat 3 feet in depth, containing 417 anodes and 418 cathodes, placed ½ inch apart. The anodes were of platinum-iridium alloy, the cathodes were of zinc. Sea-water was used as electrolyte. At Havana 216 kw. was said to have yielded 935 kgs. active chlorine per 24 hours, equivalent to 7.5 EHP-hours per kg. of active chlorine. This equals an energy efficiency of 31.5 per cent.

Although the trials at Maidenhead attracted much attention and proved satisfactory from a bacteriological point of view, they were not continued, owing to the cost of the process, and the company financing them ultimately went into liquidation.

Fixation of Atmospheric Nitrogen.*

By Prof. Philippe A. Guye.

Nitrogen, bound in form of ammonium salts and of nitrates, represents one of the vital elements of modern civilization. Besides numerous applications in the chemical arts (for instance, the use of ammonia in the production of sodium carbonate), nitrogen compounds are of fundamental importance in the industries of explosives and of fertilizers.

In view of the fact that the natural supply of Chili saltpeter is by no means inexhaustible, the importance of the problem of utilizing the atmospheric nitrogen for the production of useful nitrogen compounds is evident.

Atmospheric nitrogen is practically inexhaustible. The quantity of nitrogen contained in 1,000,000 tons of Chili saltpeter—which represents the annual consumption of Europe—is equal to the amount of nitrogen contained in the atmosphere covering 2 hectars, or 5 acres, of the earth's surface.

Two principal methods—both of which are closely connected with the progress of electrochemistry during the last decade—appear at the present time specially promising for the commercial fixation of atmospheric nitrogen. One of these methods produces calcium cyanamide (German trade name Kalkstickstoff, French chaux azotée = nitrogenated lime), by a reaction between calcium carbide and atmospheric nitrogen. The other method is based on the combination of the nitrogen and oxygen of the air by means of the electric arc.

I. Calcium Cyanamide.

Dr. Frank observed that barium carbide BaC_2, when heated to a high temperature, binds the nitrogen almost quantitatively, according to the equation

$$BaC_2 + N_2 = Ba(CN)_2$$

thus yielding barium cyanide.

When Dr. Frank tried to apply this reaction to calcium carbide, he was surprised to find that the quantity of cyanide formed was much less than the theoretical amount. Further study revealed the fact that the reaction is different from that which occurs in the case if barium carbide, and that in the case of calcium carbide it is represented by the equation

$$CaC_2 + 2N = CaCN_2 + C$$

The carbide gives off half of its carbon and changes not into cyanide, but into calcium cyanamide.

When the cyanamide is treated with water, under proper conditions, ammonia is set free according to the reaction

$$CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$$

When calcium cyanamide is distributed in the ground, the same reaction goes on more or less slowly, and it is, therefore, easily understood that cyanamide has given quite satisfactory results when used directly as a fertilizer.

On a commercial scale calcium cyanamide may be prepared by passing nitrogen gas over powdered calcium carbide, heated to a temperature of about 800° C. The reaction then proceeds without great expenditure of fuel, since it is strongly exothermic. This is the principle of the method used at present.

However, it has also been proposed to produce calcium cyanamide by treating lime, carbon and nitrogen at the very high temperature of the electric furnace. Whatever may be the method of operation the atmospheric nitrogen must be first separated from the oxygen, with which it is associated in the atmosphere.

Theoretically, the mixture of calcium cyanamide and carbon, produced by the reaction given above, should contain about 30 per cent nitrogen. As a matter of fact, the content of nitrogen in the raw calcium cyanamide product is less than this amount, either on account of the impurities in the calcium carbide or of the changes which it undergoes in course of operation. According to Frank the content of nitrogen varies between 14 and 22 per cent. The product of recent manufacture contains about 20 per cent.

Without entering into details which the industry, of course, wishes to keep secret, there can be no doubt that the production of calcium cyanamide is closely connected in principle with the manufacture of calcium carbide in the electric furnace. The necessary quantities of energy are about the same. If we want to estimate the cost of production of calcium cyanamide, containing about 20 per cent of nitrogen, for instance, and if we base our estimate on the cost of production of calcium carbide at 140 francs ($28.00) per ton—which figure is actually realized in very favorably situated electrochemical plants[1]—the kilogram of fixed nitrogen will cost about 0.70 franc (14 cents), which makes it on a par with the nitrogen fixed in ammonium salts if all costs of manufacture are taken into account.

On the other hand, experimental trials in agriculture have given quite satisfactory results with calcium cyanamide as fertilizer. Competent authorities do not fully agree as to the relative value of calcium cyanamide in comparison with ammonium salts and nitrate. It seems, however, that in various respects calcium cyanamide occupies a position intermediate between these two products.

Up to the present time calcium cyanamide was furnished by an experimental station in Berlin. The first more important plant, utilizing 3,000 hp., will be opened this year in Italy. Other similar products are also being studied.

II. Nitric Acid.

Calcium cyanamide solves only one of the economical problems of the nitrogen industry. It is a chemical fertilizer promising to be able to replace, at least partly, the Chili saltpeter and, perhaps wholly, the ammonium salts. If the present prospects should realize it will form a partial solution of the problem.

But Chili saltpeter also plays an important part as starting material for the manufacture of nitric acid, the largest part of which is consumed for the production of explosives and of powder for war, mining and general engineering purposes. In Europe the amount of nitrate consumed for these purposes represents about 20 per cent of the total import from Chili. Moreover, statistics proves that the production of nitric acid is continually increasing.

Two ways of utilizing the atmospheric nitrogen are open for this purpose:

(1) The first is to fix the atmospheric nitrogen in some way as ammonia—which may be done, for instance, by the reaction of calcium cyanamide with water—and it becomes then necessary to find an economic process for oxidizing ammonia to

* A paper read before the Swiss Society of Natural Science. Slightly abridged.

[1] The figure is given as manufacturing cost of the metric ton, and not as selling price, and refers presumably to some places in Europe where water-power may be had at a very low rate, say $5 or $6 per h.p.-year. In this country the results would be quite different.—Ed.

nitric acid. In this respect it is interesting to note that the oxidation of ammonia is strongly exothermic. The reaction

$$H_3N + 4O = HNO_3 + H_2O$$

evolves theoretically 97 calories. It would, therefore, seem that under proper conditions this reaction should proceed spontaneously.

This explains why researches have been made by various investigators with a view of realizing this transformation. But up to the present time it seems that in spite of numerous trials, tending to discover effective catalyzers, a practical solution, capable of industrial application, has not been found.

(2) The second way for producing nitric acid from air has, as starting point, an observation of Cavendish (1784), who found that nitrogen and oxygen combine slowly under the action of electric discharges to form oxides of nitrogen which then change, by more or less complex chemical processes, into nitric acid, nitrous acid, or nitrates and nitrites. The fundamental reaction is, therefore, according to the happy expression of Prof. Crookes, a real "combustion" of nitrogen in oxygen. But we may add, in order to be precise, that this combustion is "slow and lazy," since it goes on only as long as the electrical energy continues to act and since it also stops as soon as the content of nitrogen oxides in the gas has attained a certain limiting value.

For about ten years attempts have been made to devise a process of manufacture of nitric acid on this basis. I do not intend to describe in detail the various methods which have been suggested, but will summarize the general conclusions which may be drawn from these researches. I should state, however, that the first attempt of this kind, made in Switzerland, was due to Aloys Naville in 1893, who proposed to me shortly afterward to study this problem in collaboration with him and Prof. C. Eug. Guye. The results of this work were taken up in 1896 by the Société d'Etudes Electrochimiques, in Geneva, and tests have been carried out continually since that time on a moderately large scale. Other trials in the same direction have been made by the Atmospheric Products Co., at Niagara Falls (Bradley-Lovejoy method[2]), the Groupe d-Initiative in Freiburg, Switzerland (method of Kowalski[3]), and the Actieselskabet det Norske Kvaelstof Compagni in Norway (method of Eyde and Birkeland[4]). Independently of these developments, which have a more or less industrial character, very interesting laboratory researches have been made by Crookes (1897), Lord Rayleigh (1897), McDougal and Howles (1900), Muthmann and Hofer (1903), Nernst (1904), von Lepel (1903) and others.

At the beginning of these researches contradictory results were often announced. It appeared as though the effects produced would be different, according to whether the arc is produced by alternating or direct current, or whether the arc is elongated or shortened. Some have recommended currents of small intensity, others currents of large intensity. The presence of water vapor in the air has sometimes been claimed to prove favorable, sometimes unfavorable. Even the form of the electrodes appeared to play a more or less important rôle. To sum up the combustion of nitrogen at the tempreature of the electric arc appeared to be subject to very peculiar, capricious and mysterical laws, and seemed to depend on new strange factors.

All the factors mentioned above are now known to be secondary and accessory. The detailed study of the problem has proven that the phenomenon is strictly governed by the fundamental laws of chemical dynamics.

This method of looking at the problem has not only the advantage of simplicity, it also furnishes valuable indications on the possibilities which may be realized, and so far there exists good agreement between theory and experimental results. The following discussion is based upon this point of view:

[2] Our vol. I., pages 20, 100, 380, 386; vol. II., page 250; vol. III., page 285.
[3] Our vol. I., page 462; vol. II., page 152.
[4] Our vol. II., pages 390, 507; vol. III., page 23.

III. Chemical Phenomena Due to an Arc in Air.

The chemical phenomena which occur when an electric arc passes through atmospheric air, may be suitably discussed under three different headings: First, the initial reaction; second, the influence of temperature; third, the reverse reaction.

Initial Reaction.—At the high temperature of the electric arc in air, the molecules of nitrogen and oxygen dissociate into their atoms, which is followed by the combinations of these atoms to form nitric oxide.[5] The reactions are, therefore,

$$N_2 = 2N \text{ and } O_2 = 2O$$

then

$$2N + 2O = 2NO$$

Like most chemical reactions, this reaction is incomplete. This means that for a given temperature and for given initial conditions of pressure, composition, etc., the reaction stops when the content of nitric oxide reaches a certain value.

The underlying reason of the stoppage of the reaction is its reversibility. The stoppage will take place when the above reaction—the combination of the N and O atoms to nitric oxide—and the reverse reaction—the dissociation of the nitric oxide into N and O atoms—hold each other in equilibrium; *i. e.*, when in the same time the same number of NO molecules are formed by one reaction as are dissociated by the opposite reaction. The reversibility is expressed by the equation

$$\frac{1}{2} N_2 + \frac{1}{2} O_2 \rightleftarrows NO$$

It is difficult to measure the content of the nitric oxide gas in the state of equilibrium, since in the presence of an excess of oxygen (which is always the case in these experiments) the nitric oxide changes rapidly into peroxide at temperatures below 500° or 600° C.

$$NO + O = NO_2$$

The results of analysis are, therefore, generally given in form of NO_2. But this does not modify the preceding conclusions.

Effect of Temperature.—The reaction proceeds the further the higher the temperature, other things being equal. The following figures were found by Nernst and controlled by calculation on the basis of the law of mass action:

Absolute Temperature.	*Per Cents by Volume of NO, Observed.*	*Per Cents by Volume of NO, Calculated.*
1811°	0.37%	0.37%
2033	0.64	0.67
2195	0.97	0.98
3200	5.0	4.4

The time in which the limit of NO gas is formed; *i. e.*, the time in which the condition of equilibrium is reached at a certain temperature, is the shorter the higher temperature. We give some figures of the same author indicating the time during which the reaction is half completed; *i. e.*, the time in which half the above limiting values are reached. It is 100.0″ at 1,540° and 3.5″ at 1,737°.

It follows that a double advantage is derived for the combustion of nitrogen from the use of as high a temperature as possible. First, the content of nitric oxide is increased, and, secondly, the transformation occurs more rapidly.

It is true that these advantages are partly compensated by the fact that considerably more heat energy will be required at an elevated temperature, since the electric arc has to furnish the calories, raising to the desired temperature not only the

[5] Some authors have assumed that nitrogen peroxide is directly formed. But this assumption is untenable in view of the experiments of Richardson, who found that the gas NO_2 dissociates completely into NO and $\frac{1}{2}O_2$ at a temperature between 500 and 600 degs. C., which is much below the temperature of the electric arc.

nitrogen and oxygen which combine, but also the excess of the two gases which do not combine. If one makes a careful calculation, however, the larger expenditure of energy required at the higher temperature represents an expense which is more than counterbalanced by the better efficiency obtained thereby. The use of a high temperature is therefore an advantage.

Prof. F. Haber[6] gives the following figures: 1 kw.-year (of 365 days of 24 hours each) can theoretically yield the following maximum amounts of nitric acid by combustion of atmospheric nitrogen:

1850 kg HNO_3 at 4200° C.
819 kg HNO_3 at 3200° C.

A decrease of the temperature by 1,000° C. results, therefore, in this case in a reduction of the efficiency by more than 50 per cent.

Reverse Reaction.—The formation of nitric oxide at the high temperature is followed by the dissociation of the oxide into nitrogen and oxygen during the period of cooling.

This is a necessary consequence of the laws of chemical dynamics applied to reversible reactions. If, for instance, the fundamental reaction

$$\frac{1}{2} N_2 + \frac{1}{2} O_2 \rightleftarrows NO$$

is carried out at a temperature of 3,200°, whereby the limit of formation of nitric oxide in volume per cents is 5 per cent (Nernst's figure), and if the gas mixture is then cooled very slowly to 2,200° and equilibrium is again established at this temperature, the volume percents of the NO will be reduced to 1 per cent. During the slow reduction of the temperature by 1,000°, one loses, therefore, 80 per cent of the NO which was produced before at 3,200°. This is the phenomenon of the reverse reaction.

We saw before that with raising temperature equilibrium establishes itself with greater speed at higher than at lower temperatures. In the same way, when the temperature is diminished, the reverse reaction proceeds more rapidly at higher temperatures than at lower temperatures. This is also a consequence of the general phenomenon of reversibility.

It follows that the most dangerous temperatures—those in which the reverse reaction during cooling will undo what has been performed before—are high temperatures, near the temperature of the primary reaction. From this results the necessity of cooling the gas mixture as suddenly as possible from the temperature of the arc, in order to bring them in the shortest possible time to such temperatures at which the velocity of the reverse reaction is practically zero. In the case of combustion of nitrogen this condition is realized more easily, for the reason that below 600° NO combnies gradually with the excess of oxygen to form nitrous vapors which escape the reverse reaction.

In practice the tendency has been to obtain this result first by rapidly sweeping the gases out of the region of action of the arc, while more recently use has been made of electrical or mechanical devices by which the arcs were successively lighted and interrupted several thousand times per second, or the arc has been forced to play in different regions of the space. In all these cases the gas mixture which has been brought instantaneously by the arc to a very high temperature is cooled also instantaneously in the mass of surrounding cold air, and the effects of the reverse reaction are, if not suppressed, at least considerably diminished.

To sum up, the fundamental considerations which govern the combustion of atmospheric nitrogen are the following: First, it is necessary to work at a high temperature in order to increase the efficiency and the velocity of the reaction; second, to cool the gas instantaneously in order to avoid the reverse reaction.

It is at once evident that it is rather difficult to realize simultaneously these two conditions in practice. According to whether the experimenters have satisfied more or less one or the other condition, the results have apparently been contradictory. This explains the very peculiar former results to which we referred above.

The gases obtained in this way contain some 1 or 2 per cent by volume of nitric oxide when they pass out of the arc chamber, and must then be treated in order to transform the nitric oxide gas into nitric acid or into nitrates and nitrites. These operations are more of chemical than of electrochemical interest, and it will be sufficient to indciate their principle, although the practical operation involves certain difficulties. It is, indeed, necessary to handle a considerable dead weight of inert or indifferent gases. By cooling the nitric oxide gas, NO is transformed into N_2O_3 and N_2O_4 as soon as the temperature falls below 500° or 600°. Proper reactions with water, or with alkaline solutions (caustic soda, lime water, etc.), give either dilute nitric acid or nitrates or a mixture of nitrates and nitrites.

We may finally call attention to a characteristic feature which is common to all the methods which have been studied.

Whatever may be the method which is adopted, whether one operates with direct current or with alternating current, or with rapid electric oscillations in air in motion, or whether the electric discharges are displaced in space, the arc, in order to be lighted, requires a higher voltage than that which is sufficient to maintain the arc in the state of stability after it has once been established. It is, therefore, necessary to install between the source of electrical energy and the arc chamber either a considerable resistance with direct current or one or several induction coils with alternating currents or oscillatory discharges.

From a practical point of view, this means that in the arc only a fraction of the nominal capacity of the dynamo can be utilized. With alternating currents, for example, there will always be a considerable phase difference, measured by a power factor which has often a rather unfavorable value. Estimates of installations must take this point into account, since it amounts to an increase in the cost of dynamos, and therefore in the cost of the electrical energy.

The extended and expensive researches of recent years have, therefore, very greatly simplified the understanding of this problem which formerly was so mysterious. It may be interesting to briefly state what has been accomplished in practice. The best results which have been published indicate a production of 800 to 900 kilograms of HNO_3 per kw-year, measured at the arc. In order to take into account the accessory losses of electrical energy and other difficulties, it is wise to admit that in industrial practice the above figure will be reduced to about one-half and to assume, therefore, that one-half a ton of nitric acid can be produced per kw-year on an industrial scale by electrochemical processes fixing the atmospheric nitrogen.

If we take the cost of the electric kw-year as $12, which price can be realized in large installations, the energy required for producing 100 kg. of nitric acid would be about $2.40.

Now the market price of 100 kg. of nitric acid is about $9 in the state of concentrated nitric acid, and $7 in the state of virtual acid (in the nitrate at $5.20 per 100 kg.). The margin left between cost of production and selling price seems, therefore, sufficient to try, with pretty good chances for success, the electrochemical manufacture of nitric acid on a large scale, especially if the first cost of installation is not too high, which is evidently the fundamental point on which great stress should be laid.

An experiment of this kind is now actually undertaken in Norway in a plant using 2,000 or 3,000 hp.[7]

[6] F. Haber, Thermodynamik technischer Gasreaktionen (München, 1905), page 251.

[7] See our January issue, page 23.

IV. Use of Liquid Air.

We may finally say a few words concerning the rôle which liquid air may play in the development of the nascent industry of the fixation of atmospheric nitrogen.

The calcium cyanamide process needs as starting material pure nitrogen free from oxygen. Up to the present time this has been produced by passing atmospheric air over easily oxidizable substances (ferrous and cuprous salts, etc.) which absorb the oxygen of the air. Recently, in the plant in course of construction in Italy,[7] distillation of liquid air is being used for the same purpose. As is well known[8] pure nitrogen may thereby be obtained under more or less economical conditions. But in the present case the problem arises what to do with the oxygen which remains, especially if considerably large quantities are handled.

Now we have the extremely interesting fact that the combustion of atmospheric nitrogen takes place with a very appreciably better efficiency if it is carried out with an excess of oxygen. It follows that if the two industries—manufacture of calcium cyanamide and production of nitric acid by arc discharges through air—are installed side by side, they will be able to utilize both products, the nitrogen and the oxygen obtained from liquid air.

Instead of competing with each other, the two processes should, therefore, really be allies. In working together they will be in a position to bind the atmospheric nitrogen under much more economical conditions than if each process would be carried out alone. It would be an interesting development if in the way just sketched liquid air should play in future an important part in uniting the two most promising electrochemical methods for the fixation of atmospheric nitrogen on a commercial scale.

University of Geneva, Switzerland.

Containers for Alkaline and Lead Accumulators.

By M. U. Schoop and C. Liagre.

(*Concluded from page* 104.)

Containers of Sheet Iron or Steel.

The large-scale industrial manufacture of sheet-steel vessels can be carried out by different methods, namely:

1. Folding.
2. Electric welding or welding with the oxyhydrogen flame.
3. Spinning.
4. Pressing with extremely high pressures (Huber method).
5. Electrodeposition.

Folding.

According to our experience it is very difficult to maintain single or double-folded steel-sheet walls absolutely dense. This is especially the case with the bottom, while vertical seams may be easily made dense by using strong pressures. Some advantage may be derived from using proper intermediate layers, for instance, parchment, thin rubber strips, etc.

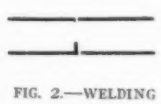


FIG. 2.—WELDING METHODS.

For laboratory purposes, it is also possible to apply a metal which is soluble with difficulty in caustic solution, from the outside onto the folded seam by means of the oxyhydrogen flame. Apparently the best metal for this purpose is copper in form of wire of 1.5 mm. thickness. With some experience it is thus possible to produce fairly good and reliable containers, which are preferably plated afterwards with nickel on the inside and outside. It is still better to use at once nickel-plated steel sheets, although they are rather expensive.

Electric Welding and Welding with the Oxyhydrogen Flame.

The practical details of these methods shall not be discussed at length at this place. Welding with the oxyhydrogen flame has been described in detail in the books of V. Engelhardt, on the electrolysis of water, and of M. U. Schoop, on the industrial electrolysis of water (Enke-Stuttgart). The principle of the method is that by means of a suitable mixing-burner, hydrogen and oxygen are mixed in the proportions of about four to one and burned, which yields a temperature at which iron and copper melt like tin, and welding seams are obtained which are very similar to the welded seams of lead sheets.

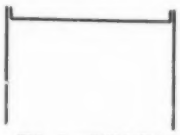


FIG. 3.—WELDING THE BOTTOM.

An excess of hydrogen is absolutely necessary for working most metals, since the flame must have reducing properties, because the atmospheric oxygen participates in the oxidation of the hydrogen emitted by the burner.

It is important that both gases have an opportunity of mixing thoroughly before burning, since, otherwise, the temperature of the flame is not homogeneous. It is easy to avoid explosions if the speed of the exit of the gas mixture is made greater than the speed with which the burning of the oxygen-hydrogen gas mixture proceeds.

While even the welding of lead sheets by this method requires some experience, the difficulties are even greater with the welding of iron and steel sheets. Two different methods of making the seams are shown in Fig. 2.

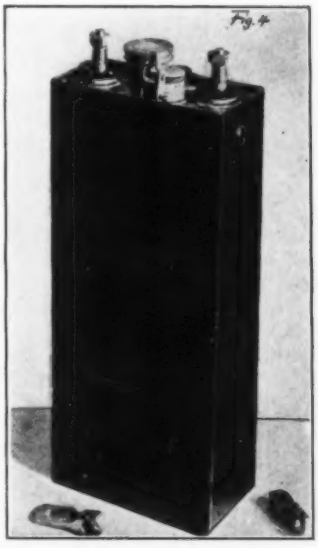


FIG. 4.—EDISON STORAGE CELL.

With very thin steel sheets distortion may easily result, which is indeed a weak point of the process in general. It is possible to prevent this to some extent by welding the seams, after having preheated the vessel to a rather high uniform temperature.

The vertical seam may be placed at will, either at an edge of the vessel or in the center of a side wall, and turns out best (*i. e.*, with very small deformation of the vessel) if some points at distances from each other are first welded, which the workingmen call basting. While the bottom offers considerable difficulties in the folding process, as mentioned above, it is a comparatively easy matter with the welding process (Fig. 3).

Every 1 meter of seam between sheets of open-hearth steel requires

Thickness of Sheet.	Time.	O—Consumption.	H—Consumption.
½ mm	4½ minutes	7½ liter, about 1½ liter per minute.	30 liter, about 6 liter per minute.
1 mm	6 minutes	2½ liter, about 2.1 liter per minute.	50 liter, about 8 liter per minute.
3 mm	14 minutes	56 liter, about 4 liter per minute	225 liter, about 16 liter per minute.

In this table it is supposed that the work is done by a skillful, trained workingman.

It is self-evident that with welded vessels there is no danger of places being not dense, since a test of the vessel will show at once any flaws.

Edison used for some time a cadmium-tin solder for his iron-nickel accumulators, but it is stated that the results obtained with it were poor. This cadmium solder has now been definitely replaced by electric welding. In Edison cells which we saw some months ago the bottom and top were welded in this

[8] See, for instance, our January issue, page 30.

way, and the boxes were provided outside with a black and well-adhering coating of paint (Fig. 4).

To be successful in welding with the electric current it is important to use the proper voltage. It is also important that the iron rod which forms one pole and from which the current passes over to the place to be heated is made negative. Another condition for perfect results with electric welding is great purity of the material.



FIG. 5.—SEAMLESS STEEL-SHEET VESSEL.

Spinning.

The method which at present seems most promising, and probably most suitable for manufacture of sheet steel vessels on a large scale, is the method of spinning, as it is used, for instance, for cartridges, scarpnells, etc. By this method the whole vessel including bottom, is made in one seamless piece. But the manufacture of spun vessels, 300 mm. high, 140 mm. long, and 90 mm. broad, with a thickness of walls not more than 0.5 or 0.7 mm., meets with extraordinary technical difficulties, so that it must be considered at present as an art, and will probably remain an art for some time to come. It is also evident that with this process each new type involves considerable expense, so that it can be profitable only if large quantities of one and the same type are to be made. While with the welding process clean, sharp corners are easily obtainable, equally sharp corners cannot be expected from spun vessels, since in this case with sharp corners no material could withstand the enormous stress.

Figs. 5, 6 and 7 show photographs of spun sheet steel vessels made of one piece. These vessels are first spun in cylindrical form, the bottom forming a cone or cap, and the change to a rectangular cross-section produces, therefore, at the bottom an excess of material which may be seen in form of four laps in the illustrations. Fig. 5 shows a vessel with plane walls, Figs. 6 and 7 vessels with walls which are corrugated, in order to increase the mechanical resistivity.

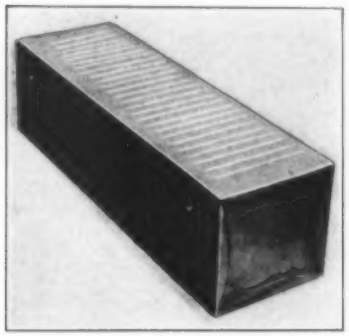


FIG. 6.—SEAMLESS SHEET-STEEL VESSEL.

A disadvantage of these vessels is that the plating of the interior with nickel offers considerable difficulties, and that in the laps in the bottom the pickling acid may stick so that it will be extremely difficult to remove it entirely.

Hydraulic Pressure.

Huber conceived the idea to produce changes of form of bodies in the interior of the press-cylinder itself. The steel sheet to be pressed is placed together with the die into the cylinder itself, which is filled with water, and by the very strong water pressure, which is uniform on all sides, the steel sheet is pressed into the die. The active element which produces the pressure is, therefore, the water, and it acts uniformly from all sides.

Since, for most metals, like iron and soft steel, the elasticity and fluidity limit is below or not much above 40 kg. per square millimeter, it is possible, by applying a water pressure of 50 kg. per square millimeter, or 5000 atmospheres, in the interior of the press-cylinder, to bring most metals while cold to the fluid state and press them thereby into dies.

The water is the active pressing material, and its pressure does not act in a single direction but acts upon the material to be treated from all sides in uniform strength.

With a hollow body with water inside and outside the pressure is the same inside and outside, and there will be a change of form only at those places where the steel sheet is closely fitted on the die, the steel being forced into the depressions of the die. In the interior of the press-cylinder it is therefore possible to produce manifold changes of form without any pounding or punching, if the following two conditions are fulfilled: First, that the water pressure is high enough to bring the steel sheet to the fluid form and force it into the depressions of the die; and, second, that the die has greater resistivity than the steel sheet, the form of which is to be changed, and that the steel sheet is closely fitted to the die.

The operation begins with filling the press-cylinder with water. The steel sheet is then fitted to the die, and the contact rims are made dense, and the whole is then placed into the water. A piston is now forced into the press-cylinder, whereby a pressure of 4,000 to 8,000 atmospheres is produced in the inside of the cylinder. The change of form begins with bending the steel sheet against the die, and completed after the fluidity limit of the metal has been transgressed.



FIG. 7.—SEAMLESS SHEET-STEEL VESSEL.

It is, of course, important that the rims where the steel sheet makes contact with the die are made dense and absolutely water-proof, so as to prevent any water of high pressure from getting between steel sheet and the die. This would, of course, be fatal for the success of the method employed.

A rectangular vessel with bottom is made as follows: A circular steel sheet of 8 to 10 mm. thickness is first preliminarily spun so as to get a form somewhat like a hat, as shown by the dark, black line in cross-section in Fig. 8. This is then placed on the box which forms the die, and the lines of contact are made dense with a proper material, as indicated at the top of Fig. 8. The whole is then placed into the press cylinder, and by means of water pressure from all sides the steel sheet (the dark, black line in Fig. 8) is pressed into the rectangular box form by means of the water pressure, which is indicated by arrows in the illustration.

To make steel boxes, 250 or more millimeters deep, the pressing operation is to be carried out in several steps, one after the other, with annealing between two successive steps. Even with the process carried out in several steps, only one die is necessary, if in the first steps of the operation a suitable filling material is used which is afterwards removed.

At the exposition at Düsseldorf, in 1902, a Huber press was shown in the pavilion of Fried. Krupp. The press-cylinder had an inside diameter of 600 mm. and a primary pressure of 530 atmospheres was produced, while in the upper reservoir of the apparatus this pressure was increased fourteen times, and thus brought up to about 7,000 atmospheres. The press was con-

nected with an electrically-driven pump giving 40 liters per minute.

Steel boxes may also be made by the Huber process by pressing in this way first the four side walls and by adding the bottom afterwards.

Electrolytic Deposition.

It is now possible to produce rather thick layers of steel by electrolytic deposition, and it is not impossible that later on this method may be made use of in the manufacture of steel boxes. Iron deposited by electrolysis is extremely hard, probably on account of occluded hydrogen, which produces on one hand great brittleness and on the other hand great hardness. Another extremely valuable property of electrolytic iron deposits is that they do not rust, and that they have a much greater resistivity against chemical influences than ordinary iron.

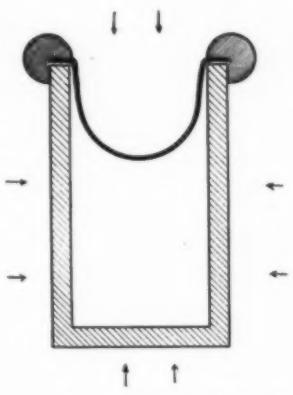


Fig. 8.—Making a steel box hydraulic pressure.

Celluloid, which is so much used with lead accumulators and which combines with transparency an almost ideal capability of being machined, cannot be used, unfortunately, for alkaline accumulators, since it is quickly attacked in solutions of 0.2 specific gravity. Only with 5 to 8 per cent solutions the attack becomes negligibly small.

The foregoing notes show that the manufacture of perfect iron or steel boxes still offers considerable difficulties, which are much greater than the production of hard-rubber boxes or sheet-lead boxes.

Finally, the proposition may be mentioned to enamel steel boxes. In this case it is no longer necessary to have the steel containers absolutely dense before they are enameled, since the enamel guarantees that the box becomes liquid proof, as is the case with many kitchen utensils, like coffee pots, etc. Riveting would, therefore, be sufficient. The enamel would also offer an excellent heat insulation, which is obtained in the Edison accumulator by a well-adhering black varnish coat; at the same time the vessel would be well insulated in electrical respect.

Jubilee of the Coal-Tar Industry.

The year 1906 marks the fiftieth anniversary of the epoch-making discovery by William Henry Perkin of the dyestuff "Mauve," by which the foundation was laid of the coal-tar industry and great stimulus given to the study of organic chemistry and chemistry in general.

At a public meeting at the Mansion House, in London, presided over by the Lord Mayor, it was decided to celebrate this anniversary in a manner befitting the importance of this great discovery. The Germans, headed by Dr. Caro, have already joined in the movement, and it is hoped that the celebration will become an international one.

In order to secure American coöperation a meeting is to be held at the Chemists' Club on April 7, 1906, at 8.15 P. M., with the object of considering what steps should be taken to give effect to the suggested jubilee celebration. At this meeting a general committee and an executive committee will be elected, and the form of memorializing the event in America, and of doing honor to W. H. Perkin, who is, fortunately, still in full activity, will be discussed. The circular of invitation is signed by Dr. C. F. Chandler and Dr. H. Schweitzer.

The Eldred Flame.

By K. P. McElroy.

What has become known to furnace-men as the "Eldred flame" is really not a flame at all in the ordinary acceptance of that term, and the word flame is only adopted for lack of a better. A flame, as usually understood, is, so to speak, a cored structure, a system of layers of different composition. There is, as in the ordinary gas jet, firstly, a core of unburnt gas; secondly, a jacketing layer on which and in which active combustion is occurring, and, finally, an irregularly stratified layer of uprushing heated air and products of combustion. This same structure is found in all common flames, whether from a candle or a reverberatory hearth. They are all cored and layered. The "Eldred flame," on the other hand, is structureless when completely developed. In lieu of combustion taking place only on or in a layer, it is occurring throughout the whole mass at the same time. It is, to borrow another term, an exploding mass with the explosion simultaneously taking place at all points; but the explosion instead of taking place in a fraction of a second, as with such explosive gas mixtures as are used in gas engines, is retarded to require as much time as may be desired, even minutes. In practice, when used in a furnace, the explosion is so timed as to require the full period of the passage of the gases through the hearth chamber, being completed just before the stack is reached.

In other words, heat is evolved in every part of the hearth chamber in lieu of being generated at some one point, generally outside, and conveyed into and through the chamber, as in the ordinary practice.

The artifices adopted to accomplish this desirable end are of quite astounding simplicity practically, though the theory of the operation is by no means so free of complexity. An ordinary grate chamber containing a shallow bed of ignited fuel is closed against access of pure air, and through the fuel is passed an accelerated draft current of air containing a regulated proportion of products of combustion, the rate of its passage being greater than the ability of the fuel to act upon it. The issuing body of gas consists of nitrogen, unchanged oxygen, unchanged carbon dioxide and carbon monoxide from the fuel, with, perhaps, a little steam or hydrogen from some coals. It is this mixture that forms the "Eldred flame." The fuel on the grate, because of the composition of the draft current, burns with relatively cool combustion, producing carbon monoxide, and though the consumption of coal per hour may, if desired, be even larger than in ordinary firing, yet the heat never becomes great. Roughly speaking, of every 100 units of heat yielded by the total combustion of carbon, thirty are due to the formation of monoxide and seventy to the conversion of monoxide into dioxide. Under the circumstances stated, dioxide is not formed and, on the contrary, much of the dioxide in the draft current is reduced with absorption of heat. The gross result is that the fire burns cool.

If a mixture of combustible gas and air be made in equivalent proportions, it is, of course, instantly exploded by being brought into contact with an object sufficiently hot to induce ignition. As the proportion of air is increased and that of combustion diminished, explosion becomes more and more difficult, until finally the mixture will not explode at all, though if a body of it be sufficiently heated from an outside source it will burn throughout its mass, though obviously, since air and combustible in the imagined case are admixed, molecule against molecule, no cored ordinary flame is possible. Such a very dilute mixture, which would not burn or explode at all on contact with a flame, would nevertheless burn if brought into the heated region of a reverberatory. It would then be in a way an "Eldred flame," but worthless for practical purposes, since the great dilution would mean useless consumption of heat in warming the excess of air, and there would hardly be enough margin of heat to keep the reverberatory region at the required temperature.

In the case just stated, while the combustion or explosion—the words may be used synonymously for present purposes—is retarded, it is done almost purely physically by the dilution. In the Eldred flame in its commercial embodiments, however, positive retarding means are employed, enabling the use of much larger relative proportions of combustible, and, therefore, the production of useful heating phenomena. Retardation is more a chemical than a physical function.

For the present purpose, the Eldred flame may be regarded as consisting of a mixture of oxygen, carbon monoxide and carbon dioxide, the presence of the diluting nitrogen being for the moment disregarded, with the monoxide and oxygen existing in about the theoretical combining proportions. Theoretically, every mixture of CO, O and CO_2 at a temperature above that necessary to institute chemical reaction must result in a product, after the reaction—if any—containing all three in certain relative proportions, with a certain "partial pressure" of each. This partial pressure of each will depend upon the temperature and certain other considerations. But, as a matter of theory, all three must be present in some relative proportions in every gas mixture containing carbon and oxygen and above a red heat. That is, for instance, if carbon dioxide itself be heated a certain amount of it will tend to split up, or dissociate, to form carbon monoxide and oxygen; this amount varying with the temperature, but, in the stated case, constant at each temperature.

The relations of the three bodies, however, become quite complicated when carbon monoxide and oxygen are not present in equivalent amounts, as they are in the example just given. Disregarding the influence of the partial pressure of the carbon dioxide in such a mixture, the amount of either the monoxide or the free oxygen is inversely proportional to the excess of the other. That is, the greater the partial pressure of the oxygen, the less is that of the carbon monoxide capable of co-existing and inversely. With a sufficient excess of oxygen, the amount of carbon monoxide, as in ordinary "complete combustion," may become vanishingly small; with a sufficient amount of carbon monoxide in excess the amount of free oxygen may approach the vanishing point. It is obvious that at the point where the two gases balance each other chemically, more of each can exist together than at any point where either is in excess. Further, and this is an important point, the velocity of the union of the two gases slows down more than proportionately as the reaction approaches the point where there remain only the partial pressures of the two gases which are capable of co-existing.

Taking the carbon dioxide now into consideration, its partial pressure in the gas mixture influences enormously the reaction between the other two bodies; the greater its amount the more of the two can co-exist without combination, and, also, the more sluggish is their reaction or combination. It has a specific retarding influence on the reaction. Put in other words, the presence of carbon dioxide tends to retard the formation of more carbon dioxide, and the greater its partial pressure in the gas mixture, the more this retardation is evident. It does not prevent the combination of carbon monoxide and oxygen beyond a certain partial pressure of each (this partial pressure of each depending on the ratio of the partial pressures of the three components and on the temperature), but it does positively slow up, or retard, the velocity with which the oxidation of the monoxide takes place.

Turning from theory to practice, in the Eldred flame there is present such a three-component mixture of carbon monoxide, carbon dioxide and free oxygen, the whole being further diluted by the nitrogen of the air and of the products of combustion. The relative ratios or partial pressures of the three are dependent on the composition of the draft current, the depth of the fuel bed and the speed of the draft; obviously all matters susceptible of easy regulation. And with this regulation will vary concomitantly the composition of the gas mass produced. With a deep bed of fuel and a slow draft, not exceeding the rapidity of reaction of the carbon, the apparatus becomes a gas producer, yielding a gas containing much monoxide and only as much of the inevitable free oxygen and carbon dioxide as the partial pressures of those two gases amount to in a mixture of that composition and temperature. Such a gas is, so to speak, in a resting state; it has no inherent capacity for reaction. If, on the other hand, the bed of fuel be made shallow and the draft current rapid, products appropriate for the Eldred flame result; products which are in a dynamic state in lieu of the static state of the producer gas.

This mixture of gases as usually produced in practice has enough oxygen distributed throughout it to combine with the carbon monoxide similarly contained, but combination is slackened both by the dilution and by the specific retarding action of the carbon dioxide. Further, the fact that there is no marked excess either of monoxide or of free oxygen likewise slackens the reaction. The result is a mixture which, while capable of burning or exploding throughout its mass, like the mixture in a gas engine cylinder, nevertheless, does so very slowly; and which, in most embodiments of the process, is of such a nature that it requires to be run into a hot-walled chamber to burn with any speed. Therein, however, under the influence of the radiant heat it burns, giving out its heat uniformly at all points within its mass. In other words, in lieu of a real flame there is a sort of ignited atmosphere filling the chamber. In its perfection the "Eldred flame" is not visible to the eye, there being no solid matter to radiate light, and the walls of a furnace fed with it glow with heat without apparent cause.

In such a furnace the development of heat is practically uniform at all points. Herein lies the great advantage of the flame for practical purposes. In the usual grate firing with production of ordinary flame, this flame is but short and lean; often, as with anthracite, extending but a few inches from the fuel bed. The evolution of heat by the fuel is intense, but it is evolved near the grate, and for heating objects further away the sensible heat of the products of combustion must be relied on—the heat of the flame gases. But sensible heat is given up to the first cooler object encountered, and the result is that a hearth chamber so heated is uneven in temperature, the parts near the entrance being overheated and those more remote not hot enough. The heating is uneven. In the case of a kiln of bricks, the bricks near the grate are over-burnt, those near the stack are under-burnt. This spottiness of heating may be, and often is, remedied in great part by running the flame reducing; using soft coal and supplying part of the air needed in the hearth chamber itself. But in the case of a reverberatory this means a long, thin flame hugging the arch and separated from the materials on the hearth by a stratum of colder air. Further, the size of the furnace which can be so heated is limited by the length of the flame which can be produced. And in any event the amount of heat is only that yielded by a film or series of films of burning gases.

With the Eldred flame, on the other hand, the possible size limits of the furnace are much extended; the heat is evolved where it is needed instead of somewhere else, and in lieu of a thin flame as remote from the material it is to heat as the limits of the hearth chamber will permit, there is an ignited atmosphere in actual contact, or as near as may be desired, with the material. Further, and this is a most important point, the character of this atmosphere, whether reducing or oxidizing, is under instant control of the furnace man. It merely requires the touch of a valve to adjust conditions as may be desired, giving a coal-burning furnace all the convenience of a gas furnace and more. And, since with the cool combustion on the grate there is no slagging or clinkering of ash, nor destruction of grate-bars and fire-box linings, it is possible to use a forced draft and burn much more fuel per square foot of grate area than is usual, thereby enabling the use of colossal furnaces and resultant economy of labor. The lack of struc-

ture of the "Eldred flame" allows it to fill any hearth chamber whatever its shape or size.

But in the embodient which has been described, it does not give any intense or localized heat; its leading characteristic is absolute uniformity of heat throughout great spaces. In certain uses it is desirable to get such a localized heat at points remote from the grate, and this has led to an interesting evolution founded on the same basic principles.

As already stated, the absence of an excess of free oxygen retards combustion inordinately. This is a familiar matter of observation, for furnace men, anxious for quick and intense combustion, always consider it necessary to admit a large excess of air over and above that chemically required; 20 per cent is a common estimate. Now, in the Eldred flame, as described, there is no such excess of oxygen, commonly there is just about enough to combine with the carbon monoxide. Therefore, at any spot in the furnace chamber where it is desired there should be an intense development of heat, a penetrating jet of air is sent through the Eldred flame. It does not carry 20 per cent of air over and above that in the flame or anything like it, thereby wasting heat, but it does supply at the spot touched a local excess of air, and in its presence combustion becomes vivid and heating intense. This air is not supplied to burn the combustible, there is enough there already for this purpose; it is added to quicken the burning by furnishing an excess partial pressure of oxygen. It is, so to say, supplied for its physical rather than its chemical effect. With a needling jet of this type an intense heat can be supplied at any spot whatever; the furnace-man not being limited by the characteristics of his fuel or his furnace; neither is he supplying an inordinate volume of cold air to the whole furnace. It is obvious what a perfect control this, in connection with the properties of the Eldred flame proper, gives over furnacing operations.

Like most inventions this grew out of a need. Mr. Eldred found the lime burners perplexed by the fact that coal burnt no more lime than wood, although it gave many more heat units, and his flame was the result. The explanation of the lack of utility of coal, after he discovered it, was simple enough —the coal flame was too short and lean, and its intense heat was of no particular avail, being merely expended in overheating and burning the lime next the grate. Calcining lime is a peculiar reaction in that it requires no great intensity of heat, but it does require a great deal of it, and, further, a large volume of hot gases to sweep off the carbon dioxide as fast as formed. In a way, it might be said that the intensity of the heat required and the volume of ambient gases are reciprocal factors. The Eldred flame with its large volume of ignited gases and its "in situ" evolution of heat, gave the necessary conditions for a cheap and profitable lime-burning method.

After gaining a foothold among the lime burners, most of whom now use it, the idea steadily grew, as is the habit of ideas, and modification after modification followed, until it is now in use in a variety of arts; but in all its avatars it has preserved the simple central idea of a slow-exploding gas mixture, burning and evolving heat throughout its mass.

Of course, the idea of returning smoke and gas to a fire to complete their combustion is a very old one; it dates back probably to the time when the first board of health and the first factory chimney were antagonistically arrayed. And the records of the patent office are full of propositions, mostly rather foolish, for making a fire burn its own smoke. None of them amounts to much, for the simple reason that without a furnace chamber capable of withstanding indefinite pressures, or as big as the atmosphere, it is impossible to keep on indefinitely returning furnace gases without an outlet—which is something that many of the inventors evidently forgot—and if any reasonable proportion, say 80 to 95 per cent, of the total products of combustion be allowed to escape there is no perceptible diminution of smoke.

But in the Eldred invention, while smoke is incidentally obviated by regulating and perfecting combustion, there is no thought of returning and burning it. The simple and beautiful underlying idea is that of mixing air with certain regulated amounts of carbon dioxide for the purpose of obtaining certain relative proportions or partial pressures of oxygen and carbon dioxide, and ultimately obtaining therewith what may be called an "auto-combustible" mixture having certain mutual relations of the partial pressures of carbon dioxide, carbon monoxide and free oxygen. Products of combustion are merely chosen as a source of carbon dioxide because cheap and convenient.

Factory Scale Experiments With Fused Electrolytes.—I.

By Edgar A. Ashcroft.

Introductory.

In this series of articles the writer intends dealing with a few special lines of practical electrolytic work with which experimental trials have been conducted on a scale comparable to factory conditions, as distinguished from laboratory experiments. The subject will be divided into several short articles dealing with: the electrolysis of fused zinc and lead chlorides, the direct electrolysis of sulphides, the magnetic stirring of fusion baths, electrolysis of sodium chloride and the production of alkali metals. Other subjects will be incidentally touched upon.

Outside the practice of a few special arts, developed for specific purposes, and associated in the public mind exclusively with individual metal recoveries or allied processes (such as the aluminium industry or the sodium and fused caustic processes, the secrets of which though, for the most part, closely guarded as to small details of practice, are, nevertheless, well known in all essential principles), but little is generally known of, and little interest seems to center in, the potential and actual openings for this line of applied electrochemistry. I place "potential" first, because the true explanation of the lack of interest and general information on the subject lies precisely in the fact that up to date the openings *are* more potential than actual (or commercial).

This is largely due to the chance circumstance that, where a particular salt (such as zinc or lead chloride) is peculiarly suitable for direct fused electrolysis, this salt does not happen to be one either widely diffused in nature or easy of manufacture from natural ores at remunerative prices and in a sufficiently pure form. It is especially characteristic of electrolytic processes (as distinguished from electric furnace methods) that very pure raw materials are essential to even moderately economical work. For the labor, breakage and general disorganization involved in any frequent dismounting and cleaning out of such apparatus as we are here considering is so great as to be prohibitory if it should become necessary as an item of regular work.

It is, therefore, usually preferable to purify the raw material rather than to produce an inferior product and subject this to a refining process (a method characteristic of most non-electric metallurgical operations). A typical case in point is the aluminium process, which, however, is sufficiently advantageously placed in other respects as to competitive methods, etc., to stand this handicap (as well as the still more severe handicap represented by the actual consumption of so expensive a form of fuel as carbon anodes are, even at their cheapest).

In spite of this actual limitation of the immediate commercial importance of the subject of fused electrolysis, a few clear ideas as to its practical bearings will be of some value to the ever-increasing army of those engaged in pioneering the ground on which may rest the commercial interests of another decade or two. Moreover, there are a few notable exceptions to the above rule which are worthy the immediate attention

of practical men, and round some of these it is practically certain that greater interest will center in the near future.

A good case serving to illustrate the less favorably placed competitors for recognition in this field, is the elcetrolysis of fused zinc and lead chlorides. When the writer first tackled this problem a good many years ago he was under the impression (an impression which still rests in many minds) that he had a very difficult problem before him. Apart from the erroneous theories mooted from time to time on the basis of wrongly conducted or badly conceived laboratory experiments (some professors a few years back were particularly guilty in this respect), there was an almost universal conviction that the practical details (refractory materials, etc.) were almost hopelessly difficult, and the necessary conditions of work consequently extremely onerous. This may be partially true where heat has to be conveyed to the electrolyte through walls of stoneware or similar material from outside sources, or where it is impossible, owing to the strong affinity of the fused metal for iron or steel (as in the case of fused zinc), to use metal containers for the exteriorly heated bath.

The actual fact proved far otherwise, however, if the bath is heated from within by means of the current; for the electrolysis of pure anhydrous fused zinc chloride with a fluid cathode is one of the easiest, cheapest and smoothest working processes which it is possible to conceive, and the same may be said, of the electrolysis of pure fused lead chloride, and of all fused electrolysis work in general where internal heating is applied, and where specific difficulties, due either to impurities or incompatible physical conditions (such as impossible fusing or vaporizing points, etc., and baleful interference of such impurities as iron salts, which cause great losses of efficiency by reason of the alternate ferrous and ferric reactions at cathode and anode respectively) do not arise.

The reason then that these operations have not yet been extensively applied lies in the fact that the salts suitable for

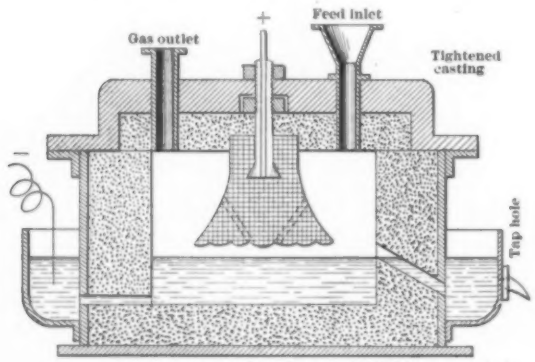


FIG. I.—VAT FOR FUSED ELECTROLYTE.

electrolysis have not yet been produced in the right commercial relation to the value of the products; not in any inherent difficulty or great cost in the electrolytic process itself. Perfectly pure anhydrous zinc chloride, for instance, is very difficult to obtain at all, and even the slightly hydrated product of commerce, and also pure lead chloride, have nearly equal market values to the metal contained; and the chlorine recovered in the treatment will seldom pay for the cost of operation.

If, however, conditions should arise where these limitations do not apply, or if it should be desired to electrolyze these salts for special reasons in spite of them; the procedure is then as follows, and I give it most willingly in detail, as it forms the basis of much of the work on derived or allied processes, which I shall describe later in this series of articles:

Fig. 1 shows the internally heated zinc vat in its latest improved form. The same apparatus in all respects is suitable for the lead process. The distinctive features of this improved vat are: the solid anode, which is cheaper and more efficient than the older forms; the means of tapping, using a continuous flow through a slanting hole into a well, which acts much like a weir, and thus maintains the distance between anode and cathode constant, and the exterior connection to the molten cathode, which enables a purer product to be obtained and is also a cheaper and more efficient construction than the steel blocks formerly employed to make connection with the molten zinc.

The apparatus needs little description. The outer casing may be of thin boiler iron, the brick lining of "Stourbridge" or simialar material, preferably made into suitable "specials" or slabs and blocks, and for the cement a mixture of zinc oxide with silicate of soda solution is employed. This cement sets quickly and makes an excellent job, impervious alike to moisture and to the fused electrolyte and clean and strong. Electrical connection is made with the cathode by means of the outer pocket, where the metal is allowed to set; the sloping passage to the second pocket constitutes a kind of weir over which the metal flows into a well before it is periodically withdrawn from the tap hole. The thickness of the lining of brick work is only of importance in its influence on the loss of heat by radiation and convection. I have used a vat quite successfully having only a 4½-inch slab lining, and though a thin lining means somewhat high volts (to compensate for the loss of heat); some advantage is also obtained by the increase of current density and consequent reduction in the size of the apparatus for a given output.

The electrical connections to the carbon block are of some importance, as these are apt to offer undue resistance and thus both absorb voltage, and give out destructive heat. The best connection for a single carbon block is secured by having a 2-inch hole some 6 inches deep in the carbon, into which is placed a hollow copper rod, 1½ inches in diameter and pierced with a ½-inch hole. This connection is then made good by means of molten lead and strengthened by any convenient mechanical-holding device.

In practice on a large scale with this process it would probably (except in special localities where power costs are high) be most economical to use a fairly high current density (1,000 amps. for 1 square foot of anode surface and 2 square feet of cathode, the anode being measured only on the under side); to employ a lining of about 9-inch thickness, and to maintain the temperature of the workroom at the maximum practical to work in (say 100° F.) by means of steam or other heaters.

The exterior casing of the apparatus never reaches a very high temperature under the circumstances of this work, and the room temperature is, therefore, relatively very important as a factor in the conservation of heat. Very little attention is required at the vats, and the occasional tapping of the zinc in such a temperature as 100° need not be a serious hardship on the workmen. A better plan still might be to enclose the vats in a kind of flue, leaving only the tops and one side (at the tapping holes) accessible. The prevention of radiation by this means is much more efficient than any amount of increase in the thickness of the lining. Any thickening of the lining inside the containing tanks is also apt to increase the cost of the apparatus considerably. But the commercial relations of these things will be again influenced by the relative cost of heat for the room and the cost of electricity.

The vat constructed as above described is worked closed and under a very slight suction (not more than ¼ inch of water gauge), and the chlorine gas may by this means be drawn off with only a slight admixture of air (it is extrmeely difficult, however, to get richer gas than 75 volumes per cent, owing to inevitable small in-takes of air, etc., through inspection holes or defective joints of brickwork and tank. When quite pure gas is required, as is the case in certain operations, a special device which I will describe later is resorted to.

The temperature of working is 450° C., and may vary quite considerably without affecting the output. The temperature

of the electrolyte must, however, be maintained above the fusing point of metallic zinc (410° C.), otherwise the formation of trees of chilled zinc between the anode and the cathode occurs and soon stops the deposits. The distance between anodes and cathodes must be very small (from ½-inch to ¼ inch), as the resistance of these salts is appreciable in the presence of such heavy volumes of current. To obtain the best results the writer always uses an admixture of molecule of sodium chloride, which remains unchanged during the electrolysis of the zinc or lead chlorides. The results then obtained are substantially quantitive, and may be calculated with perfect safety for estimating purposes as "90 per cent current efficiency."

The voltage at which such a vat can be worked may vary considerably. The theoretical voltage of zinc chloride decomposition is 2.2, and of lead chloride 1.8, but in practice, (unless electricity is very dear) it will hardly pay to work at less than 4 to 5 volts. The resistance of these salts decrease as the temperature rises, and *vice versa*, so that a perfect automatic regulation is obtained within wide limits when the vats are worked in series; an arrangement always much more practicable and convenient than any other.

The cost of outfit for this process (exclusive of plant for the preparation of the chlorides) is very small indeed, owing to the simplicity of the apparatus and the high current density employed. The carbons, when the salts are quite pure, are not consumed at all, and the construction of the vat, being solid and having everything enclosed, there need be very little accidental breakage.

The labor of charging the raw material and discharging the zinc is also trifling. The cost of the operation is thus almost confined to the cost of electrical energy, for this item bulks so large in proportion to all other costs that these seem insignificant in comparison.

The energy required per ton of zinc per annum (with vats designed so as to require 5 volts total per vat and a yield 90 per cent current efficiency) will be

$$\frac{1}{1.4} = 0.715 \text{ hp.}$$

for 1 hp.-year will produce

$$\frac{746 \times 1'2 \times 90 \times 8760}{100 \times 5 \times 1{,}000{,}000} = 1.4 \text{ metric tons.}$$

The probable cost of the cheapest average for water-power in large quantities in the near future (with capital charges added) will amount to, say, $10.00 per horse-power per year. The account will then be as follows:

Electricity	7.15
Upkeep and labor, say.....	2.5
Total cost of operating.....	$9.65 per metric ton.

The cost per ton of lead recovered by a similar process from lead chloride would be about one-third this figure, or, say, $3.00 per long ton.

These are figures which would compare favorably with most metallurgical operations were the conditions of raw material, supplies, etc., suitable. Moreover, products of the extremest purity can be readily obtained by these methods.

To bring such a process into profitable commercial operation on an extensive scale it will be necessary, therefore, either to have some extraneous source of pure raw material (such as might incidentally arise as an adjunct to some other industrial operations), or to create a cycle in which the salt suitable for electrolysis is produced cheaply and of sufficient purity.

Much of the writer's work a few years ago (in conjunction with the staff of the Metallurgical Trust, Ltd., resulting in what is now generally known under the name of the Phœnix process for treating mixed sulphide ores) was directed to this end. So far, however, market conditions have made it more profitable to supply the existing markets with zinc chloride, manufactured by these methods by the aid of the chlorine gas obtained from electrolytic alkali processes, than to produce electrolytic zinc and regenerate the chlorine.

Though, as stated above, the direct fused electrolysis of certain salts is a simple matter, other salts or raw materials present greater difficulties. It frequently happens that it is necessary to agitate the electrolyte somewhat violently, in order to prevent the settling out of solid matter, dust or impurities of various kinds on the surface of the liquid cathode. In other operations it happens that it becomes necessary to gently mix the metal of the cathode or even to cause its systematic transference into and out of adjacent receptacles. An example of the first set of conditions is found in the proposed

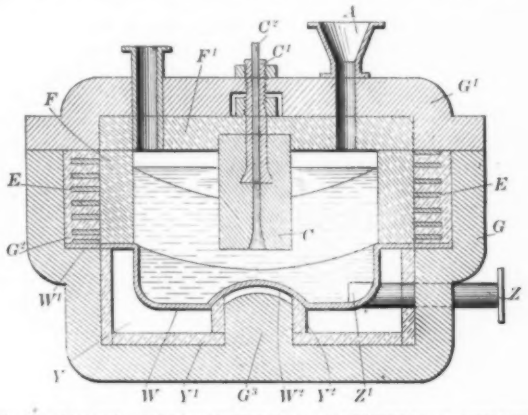


FIG. 2.—VAT FOR FUSED ELECTROLYTE. MAGNETICALLY AGITATED.

process (original patent of J. Swinburne) for the systematic treatment of mixed sulphide ores by direct electrolysis of the ore suspended in fused zinc chloride. An example of the second order is found in the writer's recently patented two-cell sodium process.

To comprehensively meet these two, and other classes of requirements the writer has devised the apparatus, the latest improved form of which is illustrated in Fig. 2. This magnetically agitated cell will be here briefly described, its special applications being dealt with later on in more detail. For the purpose of general description I cannot do better than quote from the provisional patent specification, as follows:

"This invention relates to improvements in electrolytic cells or furnaces adapted to contain fused material, the object being to provide means whereby the contents of the cells may be agitated or transferred from one cell to another. The invention is based on the same electromagnetic phenomena as the process described in the previous British patent granted to me, No. 12,083, of 1905.

"The invention is applicable in the production of sodium lead alloys from fused materials; in the treatment of sulphide or other ores by electrolysis of the raw materials suspended in a fused medium; in the, production of various alloys of metals from fused materials, and in other industrial processes.

"According to this invention an electrolytic cell containing fused material and having a substantially radial current is provided with an outer casing of magnetic conducting material, and a current-carrying coil is arranged within the casing to produce substantially axial lines of magnetic force in the cell.

"Preferably the casing of magnetic conducting material has a central pole projecting up from the base, and is covered by a lid or yolk, also of magnetic conducting material, so that the lines of magnetic force outside the coil are conducted through the casing while the lines of magnetic force inside the

coil extend between the central pole and the lid or yolk in a substantially axial direction.

"Conveniently a metal pan, forming the base of the cell, constitutes one electrode and the coil connected to the pan and carrying the electrolytic current serves to generate the magnetic field.

"In order that the cell may be heated without interfering with the coil, the pan forming the bottom of the cell is so arranged within the casing as to leave a space beneath the pan for furnace gases.

"The adjustment of the magnetic exciting effect of the coil may be accomplished by varying the number of turns of the coil in circuit, and for this purpose the several turns of the coil may be connected to a commutator or the like.

"The accompanying drawing (Fig. 2) is a transverse vertical section of an electrolytic cell illustrating by way of example one method of carrying this invention into practice.

"An outer casing G of magnet steel completely encloses the cell, and is provided with a lid or cover G_1, also of magnet steel. Within a recess G_2 in the casing is arranged a coil E of heavy copper strip, which serves as a conductor for the electrolytic current, and generates a magnetic field in the cell. A central pole G_3 projects up from the center of the base of the casing, and the magnetic field is thereby concentrated into a stream of lines of magnetic force radiating from the pole to the bottom of the lid.

"A cast steel or other metal pan W having a flange W_1 at the edge and dished in the center forms the bottom of the cell, and is supported in the casing by means of the flange W_1 in such a position that flue space Y is afforded beneath the pan for a gas fire, furnace or the like. The lower end of the coil E rests on the flange W_1, and makes electrical connection therewith so that the pan forms one electrode or conductor for the cell. The pan may have an indentation above the pole G_3 to leave an air space between the pan and the pole.

"Inside the coil E the cell is lined with a ring of refractory material F, and the cover is similarly lined at F_1. The space in the recess G_2 between the casing, the lining and the coil may be filled with suitable insulating cement to ensure the rigidity of the whole. The flue space Y is provided with a refractory tile lining Y_1, and a tube of refractory tiles Y_2 protects the pole G_3.

"A metal inlet and outlet pipe Z passes through the casing into the cell. This pipe is preferably of oval section, and may be divided into two conduits (inlet and outlet) by a partition. The partition may project into the cell to form a baffle Z_1 for circulating purposes.

"The central electrode of the cell consists of a pole of carbon or the like C supported from the cover by a composite-holding bolt C_1, having a central conductor C_2. The cell is represented as used for the electrolysis of a fused salt over a fused electrode. The passage of the main current several times round the interior of the magnetic steel casing sets up a powerful magnetic field in the cell, the lines of force being substantially axial. The lines of current flow between the electrodes are substantially radial, and the contents of the cell are thus caused to swirl violently, and this swirl may be deflected in any desired direction by suitably placed baffles.

"The advantages of this cell are: (1) That by placing the coil in the position shown, the bottom of the pan may be heated without interfering with the coil; (2) the screening effect of the steel pan is not detrimental to the magnetic effect in this form of cell; (3) the heat generated by the current-carrying coil in this case is usefully employed to lessen the radiation of heat from the fused charge through the refractory lining and the cell walls, so that the cell works economically as to voltage and current; (4) the construction of the apparatus is simple, inexpensive and strong."

It will be seen that this is a modification of the writer's former method of placing a powerful separately excited magnet beneath the cell and providing a non-magnetic bottom to the apparatus, in order to allow the lines of force to pass freely.

I shall describe some experimental applications of the above principles in my next article.

Notes on Electrochemistry and Metallurgy in Great Britain

(From Our Special Correspondent.)

The Faraday Society.

In my last letter I only described the commencement of the Faraday Society's meeting on Jan. 30. Immediately on the finishing of Mr. Minet's paper followed Dr. Harker's furnace demonstation. Dr. J. A. Harker prefaced the demonstration of his furnace by explaining its construction. The furnace which he had to show was virtually an overgrown Nernst lamp, with a glower of 70 to 75 per cent of zirconia and 10 to 15 per cent of mixed yttrite earths. The furnace shown had been produced to avoid evolution of reducing gases near the platinum, as these always affected the thermoelectric properties. The tubes produced had a cold resistance of 1,000 megohms, and the resistance remained infinite until a temperature of 450° C. had been reached. At 1,600° C. the tube exhibited took 1 amp. at 1,600° C., and was arranged with a resistance in series with it across a 200-volt main. The best tubes were made by powdering up old tubes, mixing with a suitable binding material, and squirting the material from die at about the consistency of putty. The squirted tube was carried away on a traveling belt. In use it was found that the material softened at 2,200° C., but general life was fairly lengthy if kept under the melting point of platinum. As contact was a matter of vital importance, he had heated the tube externally with a spiral of nickel wire, which extended the life of the tube itself.

A sketch of the furnace was given in Vol. III. of this journal, p. 273. Having completely described the furnace, Dr Harker then appealed to his hearers for enlightenment on one point. Had an theory been advanced by which one could calculate in advance the conductivity of any material? Upon the matter, Dr. Borns and Dr. Lowry gave references, and furnace questions poured in upon Dr. Harker. "Did the diameter of the tube affect the temperature attained?" Had he really succeeded in measuring the melting point of platinum, had he not been measuring the melting point of a platinum rhodium alloy?" "Had there been any trouble with the external nickel wire?" "Had magnesia tubes been tried?" To all of which questions Mr. Harker answered in a manner which the Proceedings will report at length. The temperature attained was not affected by diameters at present used. The melting point of platinum had been measured by placing fine platinum wire between a platinum-iridium and platinum-rhodium thermocouple. The platinum wire melted, forming a globule of pure platinum. The external nickel wire was fairly durable if encased in an outer tube. Magnesia and thoria might be used for tubes, but zirconia required a lower voltage. Gum had been used as a binding material.

The next item on the agenda was a note by Mr. E. B. R. Prideaux, "On the Production of Ozone by Electrolysis of the Alkali Fluorides," which was read but not discussed, owing to the lateness of the hour. (An abstract of this paper was given on page 108 of our last issue.—Ed.)

The Institution of Mining and Metallurgy.

Ferroalloys.

The papers presented for reading at the meeting held on Feb. 15, were purely of a mining nature, so that even their titles do not call for enumeration. The same envelope that contained these brought me the official copy of the discussion on Dr. Steinhart's paper, of which I made mention last

month. In that discussion many leading metallurgists participated, some with axes to grind; *i. e.*, alloys to boom, others, such as Mr. Hadfield, to discuss the paper in a general spirit.

Mr. Hadfield at the outset expressed his regret that there was at present a tendency to considerably advance the price of alloys and other metals used in the manufacture of special steels. His opinion was that unreasonable advances would seriously check the demand, and also turn attention to the substitution of orindary carbon steel. This might be a blessing in disguise, as no doubt in this steel, which was cheaper to produce, there were greater possibilities by careful heat treatment than was yet thought possible.

Concerning ferrochromium containing low percentages of carbon, in view of its higher cost, he did not see much advantage in its use. Nearly all steel required carbon, and therefore a certain percentage of it present in the ferroalloy was not injurious, especially as it enabled a cheaper alloy to be used. With regard to the use of tungsten for armor plates, he thought nothing had so far been done seriously. Chromium was a much cheaper element, and so long as they could get projectiles and armor plates by its use he thought makers would prefer to adhere to this metal. Of course, tungsten for high-speed tool steel was very valuable. The engineering world was much indebted to those men who had introduced tungsten by means of the ferroalloys described in the paper. Therefore, he thanked those who, like Dr. Steinhart, had done their best to bring these alloys to the notice of the steel maker.

Mr. J. Kent Smith took the discussion into a fresh region by discussing the tests to which steel should be submitted, and then dealt with vanadium steel, a subject specially investigated by him and by Captain Sankey, and described in a paper read before the Institution of Mechanical Engineers. He concluded by observing that in the development of the special steels, in whose preparations alloys, to his mind, *must* play a part, vanadium, assisted by chromium or nickel, or perhaps in some cases both, would have a "considerable amount to say."

Dr. Schack-Sommer discussed the price of nickel, and said that the most important feature in his mind in the extraction of nickel was a process which could deal cheaply with a nickel ore containing less than 6 per cent of the metal.

Mr. G. T. Holloway pointed out that, although chrome-iron ore was not readily saleable if containing below 50 per cent of chromium oxide, or only saleable at a much lower price per unit per cent than was the richer ore, the more friable varieties were more sought after than the denser mineral, and enquiries for 1,000-ton lots, apparently required for making furnace linings, etc., had been received for ore of from 40 to 42 per cent chromium oxides. In the case of molybdenite, the ore was often bought by inspection instead of by assay, and hand-picked material, such as was shown on the table, would often fetch even higher prices than the author had quoted. Ten years ago it was practically unsaleable, but the French were now using molybdenum by the ton for hardening steel. Dr. Steinhart had no doubt rightly placed tungsten third in the list of importance among the rarer metals, but he (the speaker) thought it was rapidly taking a more important position, as tungsten tool steel, etc., had properties as to hardness and retention of "temper" at high temperatures which none of the other steels possessed.

Mr. Benedict Kitto asked if Dr. Steinhart could inform them why it was that scheelite was so much objected to by the ferrotungsten manufacturers. He thought the author mentioned that it was because it was mixed with sulphur. The samples of scheelite that had passed through his own hands could have been easily treated.

Mr. A. F. Wiener discussed the sources of vanadiferous ores, and dealt with the poorness of the vanadium ores existing in California, pointing out that American users of vanadium obtained their supplies in Europe. This speaker suggested that the whole question of the employment of steel alloys was as yet barely beyond its infancy. We wanted to travel now by sea and land at twice the speed which contented the past generation. Armaments were required which were not dreamt of thirty years ago. It was quite clear that the properties of the steel of the past were no longer sufficient for all the needs of the present day, and totally insufficient for the probable future requirements. Improved materials must be found, and these would be made by the use of alloys. Chrome and nickel alloys were being used more and more, although, after all, much room yet remained for research and experiment. Vanadium has only come into notice within the last three years, but the results obtained by its use have been extraordinary. In the high-speed tool steels of the present day as much as 25 per cent of tungsten was being used. He thought that the study of these and other alloys was one of the most interesting subjects which recommended itself to the present generation.

Dr. Steinhart replied in detail to the various points raised, pointing out that low-carbon alloys were expensive articles, but they were necessary for certain steels, when it was a question of several per cent of the respective metal which had to be added to the steel, and at the same time it was necessary to keep the carbon low. He did not hold with these excessive prices, because, after all, if the manufacturers put too high prices on the metals and alloys the steelmaker would look round for others. The numbers of variations were innumerable. Mr. Hadfield's manganese steel, fortunately, did not require the use of very high-priced metals or alloys for its production, and, apart from this, it had superseded other more expensive steels (for instance, chrome steels) for many purposes. One particularly interesting use was the application of Hadfield's steel for mining machinery, the excellence of which he could testify to from practical experience.

In reply to the question of Mr. Schack-Sommer, he was not one who advocated the use of wet processes. He had seen a good many wet processes, but give him a straightforward smelting process, for it was always the best. That applied to the sulphuric acid process and the use of ammonia—all these processes had been tried, and he was afraid they had not come to much good. There was a good deal of garnierite shipped from New Caledonia under 5 per cent, and he remembered such shipments to the United States. He was much interested in what Mr. Holloway said with regard to chromite. The physical condition, such as hardness and the ease with which it is pulverized, was an important point. They all knew chromite ore was most difficult to crush, and this, for instance, was one of the expensive steps in the manufacture of chromates. What Mr. Holloway said as to the price of molybdenite he agreed with. There was no fixed price for such minerals, as often one person did not know what his neighbor paid for it.

He thought scheelite was not used so largely for this reason in melting the ore with soda ash, as a certain percentage of lime had a tendency to get into the crystals, and as the hydrochloric acid often contained sulphates, these finally gave rise to bad metal.

A cordial vote of thanks to Dr. Steinhart brought the meeting to a close.

Market Quotations.

One or two slight irregularities have to be reported in regard to the market for chemicals. At the end of February ammonia sulphate is 3s. 9d. cheaper, at £12.7.6 per ton; copper sulphate is 10s. per ton cheaper at £24.10, but zinc sulphate is unchanged, at £6.15. The soda products are unchanged, at last month's quotation. For the coal-tar products there is a good demand, and fractional increases in price have occurred. In the metal market, Cleveland warrants have closed at 49s.2d., and hematite at 63s.8d. The latest cash quotation for copper is £79. Tin has closed at £166 per ton. English lead is considerably cheaper, at £16.7.6 per ton. Quicksilver fetches from £7.5.6 to £7.7.6 per 75-pound flask.

London, March 10.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Electrochemistry.

Chlorates and Perchlorates by Electrolysis.—An interesting paper, by M. Couleru on this subject, is published in the *Chemiker Zeitung*, 1906, Vol. XXX., No. 21. Sodium perchlorate is produced electrolytically from sodium chloride as starting material. But sodium perchlorate has no direct importance for the industries, but only an indirect one as an intermediate product in the manufacture of potassium perchlorate and ammonium perchlorate by the reactions:

$$NaClO_4 + KCl = KClO_4 + NaCl$$
$$NaClO_4 + NH_4Cl = NH_4ClO_4 + NaCl$$

The perchlorates of potassium and of ammonium are used in pyrotechnics and in the explosive industries. A disadvantage of these perchlorates is their unsuitability for use in aqueous solutions, since they are no real oxidizing agents. Potassium perchlorate is only slightly soluble in cold water (15 grams per liter), which greatly facilitates its precipitation and separation from sodium chloride. Ammonium perchlorate is easily soluble in cold water (about 250 grams per liter); but since it is much more easily soluble at a higher temperature, it can be separated from sodium chloride without much difficulty. The perchlorates may be easily produced at a purity of about 99 per cent. The treatment, evaporation and crystallization of ammonium perchlorate solutions are best carried out in stoneware or enameled cast-iron vessels, steam being preferable to direct fire. The perchlorates themselves are not dangerous, but become so when strongly heated or when mixed with oxidizable substances. The manufacture of sodium perchlorate is carried out in two steps, the first being the production of the chlorate, the second that of the perchlorate.

All older processes of sodium chlorate manufacture involved considerable expenses in separating the chlorate from the chloride. This was done by evaporating the solutions containing about 300 grams $NaClO_3$ per liter. The expense was a big item, especially for manufacturers in the mountains, where fuel is expensive. All modern methods intend to avoid this expensive evaporation and complicated separation from the sodium chloride, and for this reason the manufacture is similar to the production of potassium chlorate. The electrolyte is not removed before the solution contains about 750 grams $NaClO_3$ per liter, care must be taken to always have sufficient sodium chloride present. Of electrolytic methods two are specially important for the practice, one using additions of calcium salts, the other using additions of chromate or bichromate and removal of alkali. Both methods give ampere-hour efficiencies of 80 to 90 per cent. In this way concentrated solutions of sodium chlorate are obtained which may be used directly for making perchlorate. But it is better to dissolve the raw chlorate which precipitates from these solutions and use the new solutions, since larger quantities of chloride diminish the output of perchlorate. The ampere-hour efficiency in the production of sodium chlorate is about 85 per cent, the watt-hour efficiency about 60 per cent. Platinum may be used for the anodes, iron for the cathodes. Cells up to 1,000 or 1,500 amps. as maximum are practicable. The hydrogen developed during electrolysis may be used for heating and lighting purposes, but the proper precautions should be taken.

The electrolytic production of sodium perchlorate from sodium chlorate is very simple and efficient if the following conditions are fulfilled: platinum anode, any cathode (iron being best, because cheapest); concentrated solutions of sodium chlorate as electrolyte; presence of as little sodium chloride as possible in the electrolyte, also neutralization or removal of any alkali which may form; low temperature of electrolyte, preferably between 0° and 10° C., but certainly not above 25° C. If these conditions are fulfilled the ampere-hour efficiency is only slightly influenced by current density, additions of chromate, etc. It is possible to get in the beginning an ampere-hour efficiency of 95 per cent or more, but the efficiency decreases later on, a fair mean during the whole operation being 85 per cent. The only difficulty is to keep the temperature low; this may be done by pipes placed in the electrolyte and supplied with a cooling medium or by means of internally cooled electrodes.

Kryptol.—In *Elektrotechnische Zeitschrift*, March 1, J. Bronn gives a review of his work on the use of granulated carbon as resistor for electric furnaces. This he calls kryptol. (The material which is now in commerce under the name of kryptol is not simply granlated carbon but a mixture of carbon, graphite, sand, clay and other silicates, carborundum, etc.) The author's experiments were made with a uniform material of granulated carbon; he does not think that as long as the resistor operates properly, arcs are formed between the particles in contact, since all the characteristic features of the arc, like its minimum voltage, are here missing. He designates the phenomenon rather as a kind of "transition resistance heating." When such a resistor is used for the first time from a constant potential circuit, the ohms first decrease and later increase again until they reach again about the initial value. This period he calls the "starting period." All changes of the ohms after that are simply due to variations of temperature, and the latter depends essentially upon the question whether the loss of heat by conduction and radiation is greater than the supply of electrical energy or the reverse. The author has studied in detail what happens during the starting period, and has found that the decrease and increase of resistance in that time is primarily due to a development of gases within the resistor, which results first in an increase of pressure within the mass until the gases have time to escape. This phenomenon is troublesome in practice and should be avoided; this can be done by regulation of voltage; *i. e.*, by beginning with a low voltage and increasing it slowly, or secondly, by designing the apparatus in such a way that it has a large free surface, enabling the gases to escape. On the other hand, the addition of any materials which would develop gases or vapors increases the difficulties. In apparatus which are to be used for higher temperatures it becomes necessary to replace the resistor from time to time. The author recommends to use a material of as simple and uniform composition as possible in order to avoid uncontrollable changes.

Acetylene.—London *Engineering*, of March 2, gives an illustrated description of the Atkins dry process for generating acetylene. The essential feature is that the gas is produced by mixing calcium carbide with a dry substance containing oxygen and hydrogen—ordinary soda crystals being preferred—and not with water. With washing soda the reaction is as follows: $9CaC_2 + 2Na_2CO_3\ 10H_2O = 9C_2H_2 + 4NaOH + 2CaCO_3 + 7Ca(OH)_2 + H_2O$. "The heat accompanying the reaction is very slight—not exceeding 95° C.," and therefore much below that required for the polymerization of acetylene—namely, 400° C. To this absence of excessive heat is largely due the fact that the resultant gas is perfectly free from such impurities as benzene and other complex gaseous and liquid hydrocarbons. The apparatus is illustrated.

Alternating-Current Electrolysis.—A summary of investigations on this subject, together with a list of papers relating to it, is given by H. Danneel in the *Elektrotechnische Zeitschrift* of March 1.

METALLURGY.

IRON AND STEEL.

Iron Castings for Soda Melting.—V. Portisch, in *Stahl und Eisen* for January 15, gives some special directions for casting these kettles, using a built-up brick mold, which stands as much as thirty-five castings. The Kramatorska Works, in South Russia, sells its pots with a guarantee that they will stand forty meltings; some of them have stood as many as ninety-seven. The cast iron used contains 1.5 to 2 per cent of silicon, 1.3 to 1.38 per cent of manganese, 0.15 to 0.18 per cent of phosphorus, and 0.02 to 0.03 per cent of sulphur when melted in a reverberatory furnace, but 0.07 to 0.10 per cent of sulphur when melted in a cupola. The pots made from iron melted on a hearth averaged over twice the life of those made from cupola-melted iron. This points the way towards the use of a reverberatory or an open-hearth furnace in making these castings; makers of malleable castings, already equipped with such furnaces, could very profitably take up this line of work.

Cleaning of Blast-Furnace Gas.—Director Meyjes, of Zweibrucken, discusses very fully, in *Stahl und Eisen* for Jan. 1, the present standing of this question, the paper being a report of a lecture delivered before the Southwest Germany and Luxemburg Ironmasters' Society, at Saarbrüch, on Nov. 12. The ordinary furnace gas carries 8 to 15 grams of dust per cubic meter; gas engine builders require that the gas used in their engines shall not contain over 0.02 gram per cubic meter; over that they will give no guarantee of the durability of their machines. Cowper stoves and boilers, however, work much better with the cleaned gas. Director Bian, of Dommeldingen, calculates that the higher blast temperature obtained from stoves using cleaned gas, at his works, produced a saving of coke amounting to $9,000 a year, on a 100-ton furnace; but it does not pay to take the trouble to clean the gas for the stoves and boilers quite as clean as is required by gas engines. Illustrations and detailed description of the working of six different types of cleaning plant are then given. The cost of plant, to clean 60,000 cubic meters of gas per day, varies between $40,000 and $125,000; the running costs per year $5,000 to $7,500. The detailed article will be very interesting reading to blast-furnace managers and gas-engine constructors.

Briquetting of Iron Ores.—Prof. H. Wedding delivered before the Verein deutscher Eisenhüttenleute, at their Düsseldorf meeting, Dec. 3, an interesting lecture on this subject, which is reported at length in *Stahl und Eisen* for Jan. 1 and 15. The lecture was largely historical, but very complete, and while we cannot reproduce the descriptions, yet the classification of processes is so instructive as to what has been proposed, that we reproduce it entire:

I.—BRIQUETTING WITHOUT A BINDER.

1. Moistening with water:

Cornelia mine ores, containing clay.
Used for pyrites cinders at Langloan.

2. Pressure, without heating to sintering or melting:

Cöln-Müsener Co.	Surface reduced.
Jacobi	Partial reduction.
Ronay	Heating by gas.
Daelen	Blocks pressed into a binder.
Butler	Cast iron run around them.

3. High pressure, followed by sintering:

Ronay	Very high pressure used.

4. Sintering by high temperature:

Blezinger	In revolving furnaces.
Edison	In chain furnaces.
Gröndal Co.	In rotating furnaces.
Ruthenburg	In electrical furnaces.

5. Melting:

Wedding (1865)	In reverberatory furnaces.
Thau	In reverberatory furnaces, with or without fluxes.
Stein	Melting with reducing agents.

II.—BRIQUETTING WITH A BINDER.

A.—*With Inorganic Binding Material.*

(1) With iron ores:

(*a*) With clayey ores:

Concordia Works	Lump ore and clay mud.
Henzel	Pyrites cinders and clay mud.

(*b*) With brown hematites:

Kleist	Upper Silesian brown ores.

(*c*) With purple ores:

Georgs-Marien Works	Pyrites cinders and flue dust.
Langloan	Pyrites cinders and magnetic ore.

(*d*) With flue dust:

Georgs-Marien Works	Throat dust and pyrites residues

(2) With clay:

Henzel	Pyrites residues and clay.

(3) With lime:

(*a*) With limestone:

Lang & Frey (1860)	Ore, limestone, coke.
Berthier (1830)	Slag, coal-dust, limestone.
Königer	Limestone, borax, sulphuric acid.

(*b*) With burnt lime:

Edison	Burnt lime and clay.
Wedding	Burnt lime and carbon dioxide.
Duisburg Copper Co.	Lime and ashes.
Kleber	Lime, blast-furnace slag, hydrochloric acid and steam.
Kleber	Lime, silicate, steam.
Kleber	Lime silicate, chlorides, steam.

(*c*) With slaked lime:

Straschitz	Milk of lime.

(*d*) With gypsum or cement:

Cramer	Gypsum, lime, Portland cement.
Löwenthal	Magnesium chloride and sand.
Lehmann	Magnesium sulphate and soda.
Reinke	Lime and cement.

(*e*) With lime silicate:

Schumacher	Wollastonite, from quartz and lime.

(*f*) With slag and water-glass:

Thomlinson	Cold blast-furnace slag.
Stein	Putting into fluid slag.
Kleber	Lime, slag, hydrochloric acid, steam.
Oberschulte	Blast-furnace slag and steam.
Schüchtermann	Basic Bessemer slag.
Wüst	Water-glass.
Mewes	Water-glass and asbestos.
Rouse	Water-glass and steam.

B.—*With Organic Binding Material.*

(1) With coal or lignite:

Mindary & Soudry	Coking with soft coal.
Kerpely	Coking with soft coal.
Wedding (1866)	With fat brown coal.
Dobbelstein	With fat coal-dust.
Landin	With soft coal.

(2) With tar, pitch, asphalt, petroleum residue:

Hoffelmann	Coke and pitch.
Weissmann	Soft coal and pitch.
Wedding (1890)	Asphalt or petroleum residue, with flue dust.

(3) With resin:
Edison ..... Resin soap.
(4) With starch:
Marton ..... Starch, from corn, made fluid by pressure.
(5) With residues:
Fegan ..... Naphthaline and paraffine.
Trainer ..... Lignosulphuric salts

The lecturer gave a critical discussion of the present state of this industry, after which Dr. Weiskopf, of Hanover, and Prof. Mathesius, of Berlin, added interesting remarks. The conclusion seemed to be that no one process was the best for all kinds of ores, but that each process had its strong points for some ores, in some localities, and for some particular conditions and furnaces.

Open-Hearth Practice.—The practice of using larger and larger ore charges in making open-hearth steel is receiving more and more attention—and richly deserves it. The idea of oxidizing out carbon, etc., by the slow action of the gases, while iron oxide will do it as quickly as is needed and save iron from the ore into the bargain, is rapidly being seen in its true light. C. Dichmann, in *Stahl und Eisen* for Dec. 1 and 15, gives very instructive figures respecting this subject, the eighteen large pages deserving the closest attention of all steel makers. The writer first states that "the temperature necessary for carrying out the open-hearth process cannot be attained without the presence of an oxidizing flame in the furnace," and proves this by showing that during melting down of the scrap, the charge absorbed from the gases 2.33 kilos. of oxygen per minute, and while melted absorbed 1.6 kilos. per minute. This rate of oxidation being too slow, iron ore is used to hasten the removal of impurities, but at efficiencies which are variously stated as between 0.67 and 0.90. In a careful experiment, 3,276 kilos. of ore was put into a furnace with 1,000 kilos. of limestone and 20,300 kilos. of fluid pig iron. The results confirmed the general reaction of the Monell process, and the figures showed that 85 per cent of the iron in the ore used was reduced into the bath. The slag was brought down to 10 per cent of ferrous oxide. These tests prove that fixed furnaces can be used for the pig and ore process, that scrap is not a *sine qua non*, and that Mr. Monell was a pioneer in one of the most promising improvements in open-hearth practice

Electric Power for Iron and Steel Works and Rolling Mills.—In a paper recently presented by W. J. Belsey before the Dublin Section of the (Brit.) Institution of Electrical Engineers (which is printed in the London *Electrician*, March 2), some interesting notes are given on the use of electric power in rolling mills. Since the power varies very much, the fluctuations of power would react severely on the system if no special provision was made for storing the electrical energy at the periods of light load and giving it out at moments of maximum load. This method of storing and giving out energy must, of course, be automatic. A storage battery would do, but it is cheaper and more efficacious to install a buffer machine for storing the energy in the heavy fly-wheel. A diagram of the connections is given. An interesting feature recently adopted in one of the largest steel works in Scotland has been the use of the exhaust steam from the mill engine and steam hammers, etc., for driving a steam turbine. This is arranged by exhausting all the steam from the rolling-mill engines, steam hammers, etc., into a calorific reservoir, which consists, in some cases, of a covered steel tank, which is loosely filled with pig iron or some other substance which will readily absorb heat. From this the steam is passed through a turbine, and exhausts into a very high vacuum. This idea has proved very successful in the utilizing of hitherto waste steam, for the steam which emerges under conditions of light load from rolling-mill engines and steam hammers is practically live.

Iron and Its Alloys at Liquid Air Temperatures.—Perhaps the hardest task which can fall to an abstractor is that of dealing with such a paper as that presented by Mr. Hadfield at a meeting last year of the Iron and Steel Institute. The author of a paper who, without being in any degree redundant, writes a treatise of this length, might well be pardoned if he had slightly expanded it and issued it in more pretentious manner to the world in the shape of a cloth-bound octavo book. Considering that 1,600 separate observations were made concerning some 140 distinct alloys, it will be well understood that the space at our disposal compels us to present only in a condensed form the general conclusions in which Mr. Hadfield reviews the subject.

Extraordinary effects have been produced on all the alloys examined, many of which it would have been impossible to have foretold from any known laws. Test pieces were prepared and allowed to remain several minutes in liquid air, until all semblance of "boiling" ceased. This insured each bar being reduced to the temperature of liquid air, or — 182° C. With few exceptions the effect of this treatment is to increase in a remarkable degree the resistance of iron and its alloys to tensile stress, ordinarily known as the breaking load or tenacity, and to reduce its ductility, as measured by elongation, from the highest point; for example, in mild steel 30 to 40 per cent to practically nil. The changes take place to the same extent in the softest Swedish wrought iron, and also English wrought iron, and in carbon steel samples from 0.10 per cent or 0.20 per cent to the high percentages such as 1.25 per cent or 1.50 per cent. Thus the absence or presence of carbon in ordinary carbon steel in which other special elements are not present seems to have but little influence. That there is no error in this statement is proved, independently of the tensile tests, by the fact that several bars of the Swedish charcoal iron and mild steel specimens were submitted to the low-temperature test, and tested by hand-hammer immediately after immersion. In all cases they exhibited great brittleness, breaking off instantly upon being struck with the hammer; there was an entire absence of ductility. The Brinell hardness-ball test confirmed these results, it being found that the specimen of Swedish charcoal iron (designated as "S. C. I." throughout the paper), which at normal temperature had a normal hardness number of 90, had this increased to 266, or about equal to the hardness of 0.80 per cent carbon steel at normal temperature.

The addition of nickel has a marked toughening effect upon iron at low temperatures. On reference to the detailed tests it will be seen that the purest iron, as represented by the "S. C. I.," containing 99.82 per cent iron and of specially high quality and purity becomes brittle to an extraordinary degree under the influence of the low temperature — 182° C., whereas nickel itself tested at the same low temperature has improved rather than deteriorated, not only in tenacity, which iron also does, but in ductility, in which latter quality iron entirely breaks down. If nickel, therefore, is present in an iron alloy containing but little carbon, or comparatively low in that element, it acts as a preventive of brittleness, or is a very considerable modifier of that objectionable quality.

At ordinary temperatures the toughness or ductility of nickel is no greater than that of iron. For example, in comparative tensile tests, made by the writer, of nickel and pure iron, the ductility of iron was greater. The reduction of area in the material generally shows its condition as regards ductility; in the specimens in question the reduction of area in the tensile test bars was nearly 20 per cent greater for iron in both the author's "S. C. I." and Arnold's pure iron than in the nickel specimen tested.

Iron, to a more or less degree, at any rate in manufac-

turing operations, always seems to be endeavoring to wander out of the "paths" of ductility and toughness; it is constantly endeavoring to become brittle. It will often assume its apparently brittle nature on the slightest provocation, and the metallurgist, by his arts, is always trying to correct this tendency. As with humanity, there seems to be a law of tendencies, and iron by heredity is constitutionally weak. It would appear, therefore, that iron, a cheap and convenient metal itself, must be permeated by some element that will mask or modify its properties. Until comparatively recently carbon was the only element known to modify the properties of iron; but, as will be seen in this research, this element, where great toughness is required, only helps to make matters worse.

Fortunately for the metallurgist the addition of nickel permits of the maintenance of toughness and ductility at low temperature. The explanation of this is not easy, but Mr. Hadfield suggests that, "possibly some interpenetration of the atomic mass causes a change which cannot as yet be deducted by any known chemical investigation. Iron, too, is a very crystalline metal, whereas nickel appears to be much more amorphous; it is possible, therefore, that nickel tends to prevent iron crystallizing in this manner, or prevents it cooling in such large or dangerous type of crystals. This action of nickel is simply marvellous in certain of the alloy specimens; for example, in test No. 114, which is an alloy of iron, carbon 1.18 per cent, nickel 24.30 per cent, and manganese 6.05 per cent. Here the ductility is extraordinary at not only ordinary but low temperatures, probably the highest known for any iron alloy, and certainly for an alloy having such tenacity as 84 tons per square inch. There is still present in this alloy 68 per cent of iron, yet the tendency of the latter metal to wander into the paths of brittleness is not only entirely checked at the liquid air temperature—and this brittleness, as shown so clearly in this research, occurs to an extraordinary extent in pure iron cooled to — 182° C.; but the elongation or ductility, already so great, is considerably increased, namely, from 60 per cent to 67½ per cent. There is also an increase of tenacity in both cases, namely, a rise of from 10 to 38 per cent. Thus the nickel present—as these results cannot apparently be ascribed to any other cause—enables the bar under this high tension and at — 182° C. to remain far more ductile than the very best of ductile iron of one-third the tenacity. Although the action of nickel has been specially referred to, it must not be overlooked that in this alloy there is also present 6 per cent of manganese, which in its ordinary combination with iron, that is, with no nickel present, would confer intense brittleness upon the iron and render it more brittle than if not present. This treble combination of nickel manganese with iron appears to reverse all the known laws of iron alloys."

The various changes which result in pure iron being rendered so extraordinarily brittle, and in alloys of iron with nickel and manganese being free from these tendencies, are, in the author's opinion, "not chemical, and it is rather to the physicist that we must eventually look for a full and correct explanation of the many curious results obtained in this research."

Metallography.—Prof. H. Le Chatelier gives some excellent advice on the technics of metallography in the *Revue de Metallurgie* for July. The *coarse grinding* is best done by hand on sheets of emery paper; if it is moistened with turpentine the work proceeds faster, but coarser lines are left on the specimen; if moistened with soap or paraffin the grinding goes slower, but deep scratches are avoided. (American practice has found carborundum paper still more effective.) In *polishing* it is of the utmost importance that the powders used be carefully graded, for 1 per cent of coarser grains in a fine powder will spoil the effect of the latter completely. The No. 2 emery powder of commerce is sieved between two sieves of 150 and 200 meshes per inch, and only that portion is used for coarse polishing which falls between these sizes. Emery for finer polishing is obtained by flating the emery which passes the No. 200 mesh sieve. The finest polishing is done with alumina, made by precipitating ammonia alum, and washing carefully with water acidulated slightly with ammonia, and then with very dilute nitric acid. The precipitate is then suspended in a large quantity of water, and that part used which deposits between 3 and 12 hours. The support for polishing is a piece of fine flannel stretched tight over a glass plate. The flannel is impregnated with a solution of soap, powdered emery put on its surface, spread uniformly, and then allowed to dry. The polishing may then be done on the dry surface, or it may first be moistened with water.

Methods of Attack.—The best acid in general use is a 5 per cent solution of picric acid in absolute alcohol. The 4 per cent solution of nitric acid in amyl alcohol is almost equal to it. A mixture of 1 part of 4 per cent solution of nitric acid in ordinary alcohol, with 3 parts of a saturated solution of nitrophenol in ordinary alcohol is useful, in that it colors troostite, and similar compounds, leaving the rest of the metal uncolored. By using boiling solutions of alkalies containing oxidizing agents, such as picric acid, cementite is easily colored without attacking any other constituents of steel. A 25 per cent solution of caustic soda, containing 2 per cent of picric acid, heated to 100° on a water bath, works beautifully.

Microscopes.—Prof. Le Chatelier has abandoned the use of the mercury arc lamp for illumination, because of its fragility and the length of time necessary for photographing, and prefers strongly the use of a large Nernst lamp with two filaments, each taking 1 amp. of current. The photographic camera is disposed horizontally. The details are very practical, and adapted for giving simple courses of instruction in this subject.

FURNACES.

Dimensions and Efficiency.—Dr. W. Borchers makes a splendid effort, in *Metallurgie* of Sept. 8, to compile data concerning the comparative dimensions and efficiencies of the most various kinds of metallurgical furnaces. Thirty-six roasting furnaces are compared, but with not much discrimination, so that the conclusions are only of the most general character; next, eleven lead shaft-furnaces, seventeen copper shaft-furnaces and ten copper reverberatories. The data are so numerous that the article does not admit of abstracting satisfactorily, but metallurgists in the copper and lead smelting lines will probably find the data and comparisons interesting, if not valuable.

Analysis of Current Electrochemical Patents

Electric Furnace.—M. Ruthenburg, 815,221, March 13. Application filed Aug. 14, 1905.

The object is to reduce the consumption of carbon electrodes. A layer of inert material, for instance fused slag of bauxite, floats on the fused bath (steel, etc.), and a comminuted mass of coke is placed on the bauxite. The coke serves as resistor, the carbon electrodes dipping into it. The cheap coke is consumed in preference to the more expensive electrodes. The layer of inert slag transmits the heat to the metal bath below and prevents carbon from getting into the metal bath.

Refractory Material for Electric Insulation.—D. M. Stewart, 816,270, March 27. Application filed Feb. 25, 1903.

One hundred parts by weight of finely divided steatite and twenty parts of waterglass are thoroughly mixed to a plastic or semiplastic mass of about the consistency of workable putty. The mixture is then subjected to heavy pressure in a hydraulic press, and dried in a kiln. It is finally changed into an extremely hard compound by heating it to from 1,500° to 2,000° C.

Electric Zinc Furnace.—W. McA. Johnson, 814,050, March 6. App. filed May 24, 1904.

This patent is interesting since it contains the first printed information on the extended experimental work done by the inventor at the works of the Lanyon Zinc Co. In contradistinction to the only electric furnace which is used on a commercial scale for zinc production (the arc furnace of De Laval) a resistance furnace is employed by Johnson. Two sections are shown in Fig. 1. The furnace walls (1) are constructed of fire-clay. The electrical connections are made through the side walls by means of carbon or graphite blocks (5, 6). These blocks are arranged in oppositely disposed pairs, one of these pairs being located near each end of the retort. The blocks (5-5) are connected to one pole (9), the blocks (6-6) to the other pole (10) of the electrical circuit. Over the hearth a layer (11) of refractory material (silica or high-grade fire-clay or bauxite) is distributed. Over this layer and across the furnace between the carbon blocks (55) and (66) loose masses of conductive coke (12) are arranged,

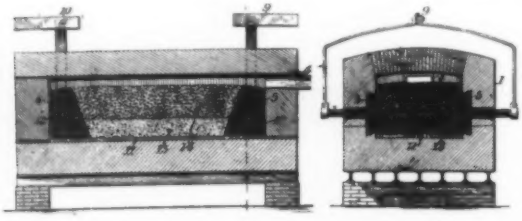


FIG. 1.—ELECTRIC ZINC FURNACE.

which constitute the active electrodes. Above the refractory layer (11) and extending upward against the side walls of the furnace, a body of high-grade ore (13) mixed with high-resistance coke is arranged, for instance roasted zinc ore containing 80 to 90 per cent zinc oxide with small percentages of iron, lime and lead, mixed with 8 to 10-mesh coke, together with sufficient fine coke to serve for the reduction. Above and within this high-resistance portion of the charge the main charge (14) is placed, consisting of a low-grade ore containing 50 to 70 per cent of zinc oxide, 15 to 30 per cent of iron, and smaller proportions of lime, lead, copper, etc., this low-grade ore being mixed with coke to form a charge of relatively low resistance. Both high and low-resistance portions of the charge are in electrical contact with the electrodes of coke (12, 12). The charges are so distributed and of such composition that the heat throughout the furnace is uniform. The layer of high-grade ore, containing little iron, protects the walls against injury from the low-grade ore; 4 is an outlet for the volatile products of the reaction.

Zinc From Sulphide.—F. T. Snyder, 814,810, March 13. Application filed June 23, 1905.

The inventor is connected with the American Zinc Extraction Co. The object is to produce zinc from blende without roasting. "The sulphide ore is mixed with carbon and with slag-forming material, and the mixture smelted upon a bath of molten slag in an electric furnace from which air is excluded, whereby the metallic sulphide is broken down, liberating the metal in a free state and forming carbon bisulphide by the reaction of the sulphur and carbon." An electric furnace provided with carbon electrodes and tightly closed to the air during operation was started by heaping scrap lead between the electrodes and melting it down by the current. Slag-forming material consisting of the zinc ore (in this case blende, containing 20 per cent Zn, 20 Fe, 5 Pb, 35 S, 20 earths-silica and alumina) mixed with iron and lime as fluxes was then fed into the furnace and melted to form a fused bath of slag, most of the lead being then tapped off. With 1,500 to 1,800 amps. at 7 to 15 volts direct current, the furnace was heated to about 1,200° C. The ore was reduced, metallic zinc being liberated in the form of vapor near one electrode, while carbon bisulphide was formed near the other electrode. "It is difficult to say to what extent the reduction of the sulphide is due to the electrolytic effect of the current as distinguished from the reducing action of the carbon at the high temperature employed, but electrolysis undoubtedly takes place, and I therefore prefer to employ direct current instead of alternating current." The inventor claims that it is entirely possible by his process to recover 94 per cent or more of the amount of zinc in the charge. To get the zinc in liquid form instead of in the form of zinc dust, the zinc vapor should be as far as possible free from diluting gases. With direct current the production of carbon bisulphide is confined to the neighborhood of one electrode, and the zinc vapor liberated near the other electrode can be kept substantially undiluted. "In the reduction of the zinc from sulphide ores to produce carbon bisulphide the proportion of the zinc vapor relative to that of the other gas is very much higher than when oxide ores are reduced and carbon monoxide produced. This is due to the fact that the production of a given volume of carbon bisulphide involves the reduction of approximately twice the quantity of ore which is reduced in producing the same volume of carbon monoxide."

Electric Furnace Process for Pig Iron Reduction.—P. L. T. Héroult, 815,016 and 815,293, March 13. Application filed June 14, 1905.

No. 815,016 relates to the process, No. 815,293 to the apparatus. The patents represent Dr. Héroult's chief ideas of increasing the efficiency of the electric furnace for pig iron production. The object is to insure that the gas escaping at the top of the furnace shall be all carbon dioxide, so that all the heat units developed by the carbon shall be developed within the furnace itself. The carbon is introduced at the base of the charge, and the latter fed into the top of the furnace without admixture of carbon. A mixture of carbon monoxide and carbon dioxide will be formed at the base of the furnace, and as this mixture of gases passes upward through the charge there will be no further consumption of carbon, but a further reduction of iron ore and a conversion of part of the carbon monoxide into dioxide. At a certain height, however, the mixture of gases is so dilute with carbon dioxide as to have substantially no further reducing effect. At this point air is blown into the furnace, and the carbon monoxide is thereby oxidized to dioxide. The higher the point where the air is blown in, the greater will be the utilization of the reducing power of carbon monoxide, though such reducing power is a diminishing quantity. The lower the point of injection of air the greater is the heat developed and the less the reduction of ore. The reduction of 1 kg. Fe from Fe_2O_3 requires 1,640 calories; the oxidation of 200 grams C to CO_2 furnishes this energy; in addition the process requires sufficient heat to melt the iron and slag, namely, for 1 kg. Fe 250 calories, and for 0.5 kg. of slag 250 calories, a total of 500 calories; 200 grams of carbon and 1 electric hp-hour (= 630 calories) will, therefore effect reduction and smelting and provide an excess of 130 calories for losses by radiation and the heat escaping with the gases. The furnace is shown in Fig. 2. The pulverized carbon is introduced through the hollow electrode *B*, and forms at the base a sort of mushroom *O* surrounding the lower end of the electrode and serving, in fact, as the working electrode. The molten metal *P* collects at the bottom, and is drawn off from time to time through the tap-hole *A*. The molten slag *Q* floats on the top of the molten metal *P*, and shades gradually into the solid charge above. The oxygen

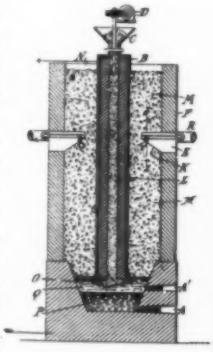


FIG. 2.—ELECTRIC IRON FURNACE.

of the ore combines with the carbon, while the iron is melted and trickles in drops through the lower part of the charge and the slag to the pool beneath. The carbon monoxide and dioxide formed with the oxygen of the ore then pass upward through the ore, taking oxygen therefrom in gradually diminishing quantities. The electrode *B* is protected by an iron shell against the carbon dioxide. The remaining monoxide is oxidized by air blown through the nozzles *E*.

Treating Copper-Nickel Matte.—W. McA. Johnson, 814,049, March 6. Application filed May 27, 1903.

The important industrial problem which this patent intends to solve was summarized in an editorial in our January issue, page 1, while two patents of Hybinette, relating to the same problem, were analyzed on pages 33 and 34 of the same issue. Like Mr. Hybinette, Mr. Johnson was formerly connected with the Orford Copper Co.

The copper-nickel matte to be treated may contain 39 per cent nickel, 39 per cent copper, substantially 1 per cent of iron and cobalt, and 20 per cent of sulphur, together with small proportions of platinum and palladium. The crushed matte is treated with hot sulphuric acid (concentration 5 per cent, temperature 80° to 100° C.), yielding hydrogen sulphide, a mixed solution of nickel, cobalt and iron sulphates, and a residue "R." The hydrogen sulphide is burnt to sulphur dioxide. The sulphate solution is freed from cobalt and iron by treatment with chlorine and caustic soda or sodium carbonate, or by the action of hypocholrites. The resultant nickel sulphate solution is treated with caustic soda, whereby the nickel is separated as hydrate. By means of neutralization with sulphuric acid nickel hydroxide is then dissolved and the nickel sulphate solution is electrolyzed, nickel being deposited on the cathode, and an equivalent amount of nickel hydrate being added to keep the solution neutral.

The residue "R" from the acid treatment of the matte consists chiefly of copper sulphide, some undissolved nickel sulphide and small quantities of platinum and palladium. This residue is roasted to oxide and then treated with sulphuric acid, yielding a solution containing, say, 9 per cent of copper and 1 per cent of nickel, in form of sulphates. This solution is electrolyzed with inert lead anodes, while the gases from the roasting operation are passed through the electrolyte. The gases serve the double purpose of reducing the necessary e. m. f. by their depolarizing effect and of yielding sulphuric acid needed later for leaching the residue. The electrolysis is continued until the copper content is reduced to about 0.8 per cent, and the acid electrolyte is then returned to the vats for leaching the roasted residue. Then follows again electrolysis, etc. When the nickel content in this copper electrolyte has risen to such an extent (say 8 per cent nickel) as to interfere with the deposition of copper, it is electrolyzed in a second series of vats with revolving cathodes until the copper is reduced to 0.4 per cent. The electrolyte is then returned to the vats for leaching the original matte.

Reduction of Galena.—C. P. Townsend, 815,881, March 20. Application filed April 12, 1902.

The object is to reduce galena in a fused bath, consisting of a haloid salt of an alkali or alkaline-earth metal. The lead is obtained in the fused state by cathodic reduction. By reason of the great difference in specific gravities the ore floats upon the surface of the lead beneath the electrolyte, and remains, therefore, in the field of most active reduction until it is itself reduced, and any irreducible impurities which may be present in the ore collect above the lead and are removed in any suitable manner. A high current density may be used and the reduction proceeds, therefore, with great rapidity. In operation the electrolyte is fused in a vessel and the charge of galena added, a cathode connection being made to the charge, preferably by means of a pool of lead upon which it rests. Anodes of carbon or graphite are located in the molten bath in proximity to the charge. As an alternative construction the lead ore may be placed in a basket or perforated holder, the cathode connection being made preferably to the central portion of the body of the ore. Upon the passage of the current the ore is reduced and the molten lead escapes through the perforations to the bottom of the fusion vessel. Since no oxygen is present in the bath or ore, anodes of retort carbon or graphite may be used without undue consumption. The sodium liberated from the molten bath combines at once with the sulphur of the ore, with the result that the electromotive force required for the decomposition of the electrolyte is correspondingly reduced. A certain amount of sodium sulphide is thus formed, which accumulates in the bath until it is sufficient in quantity to carry the current. Thereafter sodium sulphide alone is decomposed, sulphur distilling or burning around the anode, according as access of air is prevented or permitted. Since the sodium sulphide is decomposed at a lower electromotive force than the haloid salts, the power consumption decreases. Thereafter the electromotive force required is merely that necessary to overcome the ohmic resistance of the bath. Since the electrolyte is inert toward galena in all stages of the process, no metal exists in solution. This is important, as otherwise unavoidable losses of electrolyte would entail loss of metal.

Mercury Cathode Cell.—W. E. Harmon, 814,692, March 13. Application filed July 6, 1905. (Assigned to American Electrolytic Co.)

To secure the best results in producing sodium amalgam by electrolyzing common salt with a mercury cathode, the electrolyte should be kept free from an excess of hydrates, and it has been proposed to add acid to the electrolyte for this purpose. To accomplish the same end the inventor uses a small quantity of granulated carbon on the mercury surface (1 gram per square foot). This maintains the electrolyte acid.

Deep Etching of Zinc by Electrolysis.—O. C. Strecker and H. H. Strecker, 815,875, March 20. Application filed may 26, 1904.

In the electrolytic production of deeply-etched zincographs and relief-etchings for lithographic metal printing, troubles may arise from the use of impure zinc, resulting in an irregular solution of the zinc, so that a rough, unequally-bitten etched ground is obtained which takes the color and is printed off. This disadvantage is overcome by using a high current density, not less than 2 amps. per square centimeter of one-sided anode surface (maximum 12 amps.). A 10 per cent zinc acetate solution is used.

RECENT METALLURGICAL PATENTS.

Precious Metals from Zinc Ores.—In a patent recently granted (815,614, March 20) the late A. R. Meyer, proposes to avoid the expense of the double treatment, of which the first step is distillation of zinc and the second step a subsequent treatment of the residual matter for the recovery of the precious metals. In order to accomplish both results in one operation, the pulverized zinc ore is mixed with finely divided copper (or copper ore or lead or lead ore) and with carbon for reduction. The mixture is placed in a retort. The zinc distills off, while the copper acts directly upon the precious metal contents of the charge, extracting the same and combining therewith, forming a product either of metallic regulus or sulphides, forming matte, which may either gather in a mass, or, as is more usually the case, collect in globules throughout the charge in the retort.

Nickel.—The well-known Mond process consists essentially in heating nickel oxide in a reducing gas at a temperature between 350° and 500° C., cooling the material to 50° C., and subjecting it to the action of carbonic oxide gas, whereby the nickel is volatilized in the form of "nickel carbonyl" (our Vol. II., p. 291). In the original patent it is stated that while 50° C. is the preferable temperature for the carbonic oxide treat-

ment, yet it is possible to work at temperatures from 0° to 150° C. Carl Langer (815,717, March 20, assigned to Mond Nickel Co.) refers to the fact that on a manufacturing scale varying and low yields of nickel carbonyl have been obtained, for the reason that the range of temperatures from 0° to 150° is not at all permissible if the process shall be commercially successful. It is essential to keep the temperature carefully between 40° and 50° C. at atmospheric pressure. Merely cooling to 50° C. is also useless, since the reaction between nickel and carbonic oxide evolves heat so that the temperature would rapidly rise again. It is, therefore, necessary to apply artificial cooling. Langer describes apparatus for this purpose.

Precious Metals from Finely Divided Hydrometallurgical Products.—In refining the finely divided precipitates from cyanide, chlorine or hyposulphite solutions by the ordinary crucible method, considerable losses are encountered from "dusting." They may be avoided, according to C. W. Merrill (815,851, March 20), by the following process. The finely divided material is mixed with litharge, a soluble lead salt is added, and with the aid of a binding material—molasses or lime—briquettes are made. These can be introduced into the cupola without fearing any losses. In the cupola the litharge is reduced to metallic lead, whereupon fresh material is added periodically. The lead collects and contains the finely divided precious metals and is then cupelled off and recovered as litharge, to be used in subsequent operations. The precious metals are obtained nearly pure and may be cast or remelted into bars.

Modification of Cyanide Process.—T. B. Joseph (814,452, March 6) patents a leaching solution, containing water, sodium cyanide, hydrate of calcium, barium dioxide, ammonium bicarbonate, with the application of compressed air. The cyanogen in the solution extracts the precious metal, while the ammonium is intended to cause a better extraction of the silver as well as of the gold than could be obtained by the straight cyanide process. If there were no carbon with the ammonia in the solution, then the ammonia might decompose some of the cyanogen into its component parts and destroy its power to dissolve gold. If there are any of the ferrocyanides of zinc the ferrocyanide of copper, the zinc cyanide, the sulphur cyanide or the ferrocyanides remaining in this solution, any of them are also good solvents of the gold, as the barium and compressed air neutralize the injurious parts of sulphur and iron. Many of the injurious salts of iron, arsenic or sulphur are readily oxidized by the process or transformed into compounds insoluble or inert as to the solution.

Copper.—A. Elliott proposes the following process for winning copper from low-grade ores containing such quantities of bases (lime, iron, etc.) as to make them unavailable for leaching by acid solutions. He proposes to leach the ore with a non-acid, hot ferrous-sulphate solution while air is passed through the solution. The copper, if in form of an oxide, will dissolve as sulphate, from which it is precipitated afterwards. The inventor gives the following reaction: First, action of air $6FeSO_4 + O_3 = 2Fe_2(SO_4)_3 + Fe_2O_3$; second, leaching $Fe_2(SO_4)_3 + 3CuO = 3CuSO_4 + Fe_2O_3$; third, precipitation $CuSO_4 + Fe = Cu + FeSO_4$. The leaching solution is therefore regenerated.

BOOK REVIEW.

Cyanide Industry, Thoretically and Practically Considered. By R. Robine and M. Lenglien. Translated by J. A. Leclerc. New York: Wiley & Sons. Price $4.00.

This book comes at an opportune time, and fills, in an adequate manner, a real need. Beginning with a careful study of the chemistry of cyanogen and its compounds and derivatives, the reader is made acquainted in Chaper III. with the general properties of and with all methods of practical analysis for cyanides and cyanogen compounds. The end of Part I. is devoted to thermochemical data.

Part II. is a brief, and somewhat inadequate, treatment of the commercial and statistical sides of the subject. Here the statistics, though interesting, are out of date (the world's production of cyanide being stated no later than 1899, and no figures of consumption at all since the war in the Transvaal, for instance). Some information is given as to the actual and relative production, consumption and makers of cyanides, ferrocyanides, ferricyanides and sulphocyanides, but there is no connecting sequence to enable the general reader to reach a comprehensive grasp of all the bearings of this complicated industry.

Part III. is devoted to a very full and valuable account of actual industrial processes, used or suggested, for the manufacture of cyanides, ferrocyanides, sulphocyanides, cyonates and other salts of potassium, sodium et alia, finishing with some account of the Prussian blue industry. For this part of the book, which is about two-thirds of the whole, we have nothing but praise. A great deal of information hitherto unpublished, or only obtainable by searches in isolated records of technical "proceedings" and journals is placed at the reader's disposal.

Adequate treatment is given to three leading industrial methods in use for obtaining commercial cyanides. (1) From the gasworks by-products of ferrocyanide (chiefly by the aid of metallic sodium). (2) The so-called synthetic methods using metallic sodium, carbon and ammonia gas, of which Castner's process was the first, and the latest modification is the cyanamide process, due to the industry and enterprise of the Deutsche Gold-und Silber-Scheide Anstalt, whose American offshoot is the Roessler & Hasslacher Chemical Co., of Perth Amboy. (3) The nitric acid or nitrate and sulphocyanide methods, due to Raschen & Brock, and operated by the United Alkali Co., of Liverpool.

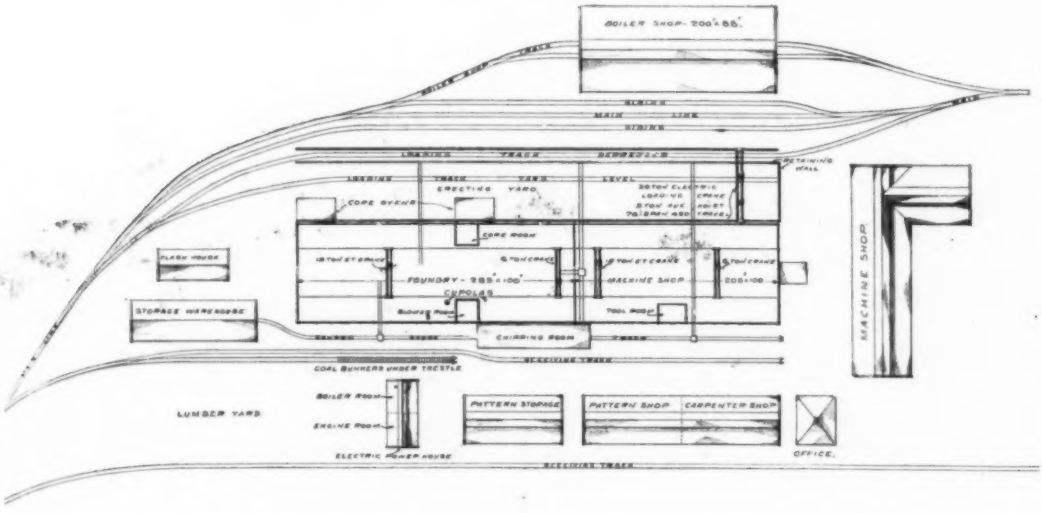
Part IV. treats of the *uses* of cyanogen compounds, and as far as it goes, is good. A very brief chapter of conclusions contains also a few useful comparative data of costs and values, and the general conclusion is drawn that the only real and abiding success attained amid the great rush of competitive processes rests with the methods using metallic sodium, either as a base for combination with ammonia and carbon, or as a reducing agent for ferrocyanide recovered from the spent oxides of gasworks. It is stated that the simplest of all methods, viz.: the fusion of ferrocyanide of potassium with metallic sodium, resulting in a double cyanide of 100 per cent quality (a method largely practiced by the Gas Light & Coke Co., of London, but attributed by the author to the American firm of Roessler & Hasslacher Co.), is economical when the cost of metallic sodium falls below 250 francs (French) per 100 kilos. (or 22.7 cents per pound). In fact, it would seem evident from the author's conclusions that the future of this industry largely rests on the commercial relations of the metal sodium. The concluding chapter finishes somewhat irrelevantly with some thermochemical and other tables.

The book concludes with a somewhat bulky and unnecessary reprint of some departmental summaries of metallurgical patents, very imperfectly related to the subject in hand. In this and other respects the book bears traces of amateur editorship, if not of too hasty compilation. In spite of these minor faults, and some small defects of printing and get up, it is an admirable work, and one which, coming as it does at a time when the expiration of the sodium monopoly is within sight, owing to the expiration of patents and other causes, and cheaper cyanide becomes, consequently, a possibility of the near future, it cannot fail to find a warm welcome in many quarters. We cordially praise the author's painstaking and able endeavors to present a text book of a class much needed.

New Works of the Traylor Manufacturing and Construction Company.

Several recent notable metallurgical plants designed and erected by the Traylor Engineering Co., of New York City, have brought this enterprising concern into the front rank of metallurgical interest; this is not surprising when it is known that the officers of the company are engineers, who have had a continuous practical experience of from fifteen to twenty-five years.

Last year, in our Vol. III., pages 122 and 163, we described at length the new mill of the Green Mountain Mining & Milling Co., of Silverton, Col., which is one of the most modern and efficient concentrating plants in this country. This plant is interesting not only on account of its compact design, which is due to the Traylor Engineering Co., but also on account of the extensive use of the Traylor centripact-screen. In one of our next issues we will give a description of a unique plant, also in Colorado, in which the final stage of operation



PLAN OF WORKS OF TRAYLOR MANUFACTURING & CONSTRUCTION CO.

will be closely allied with the latest developments of electrometallurgical engineering, while the crushing and leaching works were designed by the Traylor Engineering Co. These are only two isolated instances of the progressive work which the Traylor concern is now performing. A better idea of the extent of the business of this company may be had from the following brief description of their new works at Allentown, Pa.

Allentown was selected as the most desirable place for the works, after the resources of the country immediately adjoining New York City had been thoroughly tested. The company formerly had works at Belleville, N. J., but it seemed almost impossible there to solve the labor problem, since the class of workmen which could be depended upon for getting out the special line of products manufactured by the Traylor Co. could not be secured at that place. The Belleville works were therefore abandoned, and a special site was secured at Allentown with room for extensions. Entirely new works have recently been erected, where all the work of the company will be carried out in future. There are already a notable number of pig iron plants, foundries, machine shops, textile mills in and around Allentown, which, moreover, is the geographical center of the greatest cement industry in the world. The population of Allentown is made up mostly of Pennsylvania Dutch, who are exceedingly conservative in their views and as a rule are good mechanics. In this sense Allentown represented the best possible solution of the labor problem. On the other hand, the city is only 90 miles from New York City, and can be reached by three different railroads; it is 60 miles from Philadelphia, 5 miles from Bethlehem, 35 miles from Reading, and has direct railroad connection by several different lines with Pittsburg, the great iron and steel center.

The location of the works at Allentown has also brought the Traylor Co. into closer connection with the cement industry. The initial connecting link was the centripact screen, which we described in detail in our last volume, as noticed above. While the screen was primarily designed for screening all kinds of ore products, for use in mines, mills and smelting works, it has now been found that it is quite as important in the manufacture of cement. The Traylor Co. has, therefore, decided to go into the general manufacture of all kinds of cement machinery, and by designing a modern and very powerful crushing roll (to take the place of ball mills, heretofore used for reducing cement-making material down fine enough to pass a 16-mesh screen), the Traylor Co. has pushed its business into the cement industry, and it is expected that the use of the rolls will result in an appreciable saving. The company has also decided to build tube mills, kilns, sand-lime brick machinery, stone and rock crushing plants, etc.

The officers of the Traylor Manufacturing & Construction Co. are Samuel W. Traylor, president and treasurer; Bruce W. Traylor, vice-president; Frank W. Hopkins, assistant treasurer, and P. Edwin Van Saun, secretary and chief engineer, all of whom are engineers and have had long, continuous experience in the manufacture of their class of machinery.

The Traylor Engineering Co., of New York City, is made up of the same officers, and they own exclusively all of the stock of the Traylor Manufacturing & Construction Co., and all of the products of the Traylor Manufacturing & Construction Co. are handled exclusively by the Traylor Engineering Co. All contracts for plants are taken in the name of the Traylor Engineering Co. The two companies are, however, operated entirely independently of one another.

Mr. C. C. Knauss, one of the founders of the Bethlehem Foundry & Machine Co., and later manager of the Allentown Foundry & Machine Works, is the manager of the Allentown Traylor works.

In addition to the general machinery business carried on by the Traylor Engineering Co., they act as consulting metallurgical and mechanical engineers for any one requiring their services. They are now designing some of the largest ore reducing plants in the United States. They have been closely identified with the designing and building of many of the most successful plants now in operation. At the present time they have under construction and nearing completion several large plants after their own designs.

The new works at Allentown consist of an office building, carpenter shop, pattern shop, pattern storage shop, power house, machine shop, foundry, flask house, storage warehouse, boiler shop, where sheet steel and blacksmith work are done, with large erecting floors and a lumber yard. The foundry is equipped with two large cupolas, one of which is probably the largest used in the vicinity of New York City, being of such a size as to make castings in single pieces weighing 50,000 pounds. The foundry is equipped with all the most modern devices, including electric traveling cranes, and, in fact, is built along the most approved designs, for the purpose of producing castings at the least possible cost, and is of such a size as to enable the company to have an output of from 40 to 50 tons per day. In this branch of their business alone the company will employ 150 to 200 men.

The machine shop and the foundry are each equipped with two traveling cranes running the full length of each shop, and covering the full width of the main working floors. One crane in each shop is of 6 tons capacity, while the other is of 15 tons capacity.

The machine shop is equipped along lines especially suitable for the production of the special class of machinery to be built. No expense has been spared in acquiring tools that are particularly adapted for their purposes, and many tools were made for the company's special purposes. This shop contains several giant machines weighing 75,000 to 100,000 pounds each, such as boring mills, open slide-planers and large lathes. All of these are accessible to the use of the heavy overhead traveling cranes, so that the handling of the ponderous machinery made by them will involve but a small consideration in cost or time. The turret lathes and other smaller machine rolls have smaller traveling cranes running above them for their accommodation.

The machine shop has a tool room built within it, and in the foundry there is a blower room and a core room. Outside the foundry but adjoining it are two core ovens.

The erecting floors adjoin the foundry and machine shops. Two loading tracks pass lengthwise through it. One of these is at the ground level, the other depressed.

Over the erecting yard and loading tracks runs an enormous electric traveling crane, whose span is 76 feet, hoist 30 feet, and runway 490 fet long. The crane carries a main hoist of 30 tons capacity, and an auxiliary hoist of 5 tons capacity.

The sheet steel and blacksmith shops are equipped along like lines, being provided with a large number of jib cranes in addition to a large double-track crane spanning 50 feet. This large crane will be used principally for assembling heavy blast furnaces, such as the company makes a specialty of designing and building. The blacksmith shops are all equipped with the very best tools for their work, such as hydraulic presses, steam hammers and trip hammers.

Adjacent to these shops are a pattern and carpenter shop, which measures 75 feet x 200 feet, and is two stories high. This is equipped with the most modern woodworking tools. The company have also a very elaborate, well arranged and commodious office adjoining the woodworking and pattern shops.

The erecting floors are of such a size as to require the overhead traveling crane, with a lift of 30 feet, a span of 76 feet, and a horiznotal travel of 490 feet. This crane enables the company to load heavy machinery on outgoing cars, and to unload all incoming cars at a nominal cost. This ponderous crane is of the greatest importance in cheapening the cost of manufacture, especially with such products as are made by this company.



ALLENTOWN WORKS OF TRAYLOR MANUFACTURING & CONSTRUCTION CO.

The power plant consists of two 204-hp. water-tube boilers, an air compressor, and two Corliss engines, direct connected to two 100-kw generators. The current is transmitted to the different parts of their works for operating the machines. The entire plant is operated electrically, including all of the numerous hoists, large and small. A compound air compressor furnishes air for all of the chipping and riveting hammers, and to every part of the works where its use is required.

A general warehouse and storeroom, 100 feet x 200 feet, is now in course of construction along the railroad siding.

All of the buildings are strictly modern, being constructed with brick walls and roofs of slate. They are provided with ample light in every part.

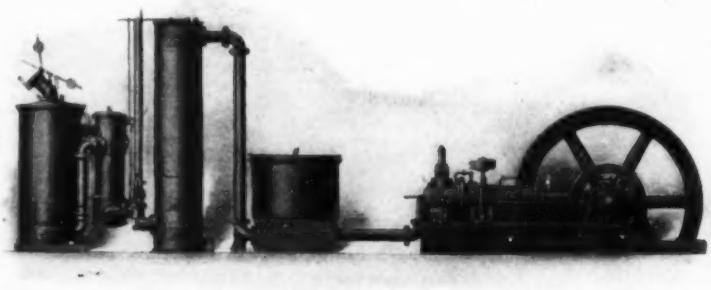
The company has a most desirable location in the matter of railroad facilities, having 1,800 feet along the railroad tracks, and a track of land consisting in all of about 19 acres. The trackage arrangements are perfect. They now have under contemplation plans for largely increasing the size of their plant in the near future. Including all, the amount of floor space in the new works is now about 100,000 square feet.

Suction Gas Producers.

By Oskar Nagel, Ph. D.

While in Germany, suction gas-power plants are a decided success, which can be seen from the fact that Koerting Bros., for instance, have sold over 4,000 plants in the last four years, some suction gas-power plants built in this country have proved a failure. The main reason that some of these American plants have not been successful is to be looked for in the gas engine. American gas engine builders are accustomed to work with highly efficient gases, such as natural or illuminating gas, and when building their engines for the use of producer gas they have just made some slight changes, which are not sufficient to insure good and continuous working with producer gas. A large number of American gas engines are built very light and working with high speed. A producer gas engine, on the contrary, has to be heavily built, and if to be used for continuous work it has to be a slow-speed engine. As producer gas is hardly ever absolutely pure the valves have to be so arranged that their working is not interfered with by small impurities. For places with changing load an extremely heavy fly-wheel with great momentum has to be used so as to help the producer over the first period of change. Furthermore, a good mixing valve has to be attached to the engine, as without this the economical running of the engine is impossible.

All these points have been carefully considered by Koerting Bros. in constructing their engines. Their mixing valve supplies the cylinder with a perfect combustible from the first revolution and greatly facilitates starting, which gives this engine an inestimable advantage over other types. The mixing valve is so constructed that the stream of incoming gas is split up into a number of small streams flowing at right angles to the incoming air, this mixture being again passed through another set of ports, which impart to it a whirling motion and insure perfect mixing of the two constituents before they are admitted to the cylinder.



SUCTION GAS PRODUCER PLANT.

A 75-hp. Koerting engine and suction producer, such as shown in the cut, is now running in the works of the De La Vergne Machine Co., New York, and consumes less than 1 pound of coal per brake horse-power-hour. The engine is a 4-cycle single-cylinder engine, running at 162 r. p. m. The producer plant consists of producer, evaporator, wet scrubber and sawdust scrubber. The producer is a sheet-iron shell, lined with fire-brick and provided with poke holes and double hopper, also with large fire and ash doors. The evaporator is of the tubular type, and is provided with an extremely well designed air inlet. The wet scrubber is of the ordinary type, and provided with three doors, while the sawdust scrubber contains two wooden trays, one covered with shavings and the other with sawdust.

It is probably worth mentioning that most of our power plant engineers, while thoroughly familiar with steam power, are not so well informed relative to gas power. They, therefore, ought to take care when buying a gas power outfit to get thoroughly posted regarding the actual performance of the engine and producer that is offered to them. In forming a decision the intrinsic value of the plant ought to be exclusively considered, and not the more or less inconsiderable saving in the first cost.

If this had been done with the plants installed up to now in this country, much disappointment and trouble would have been avoided.

Apparatus for Lifting Solutions by Compressed Air.

However beautiful and sound in theory a chemical or metallurgical process may be, its successful carrying out on a commercial scale will mainly depend on the proper construction of the mechanical apparatus involved in its operation. Such little things like stoppage of a valve or leakage of a joint may cause innumerable troubles and the continued repetition of accidents, due to small mechanical defects, has more than once relegated a good proposition to the scrap heap. But even in commercially successful processes, the losses due to interruptions by mechanical accidents are not always small, and the cost of maintenance and repairs is often unnecessarily high. For this reason any decisive improvement in the construction of indispensable apparatus is always a matter of importance.

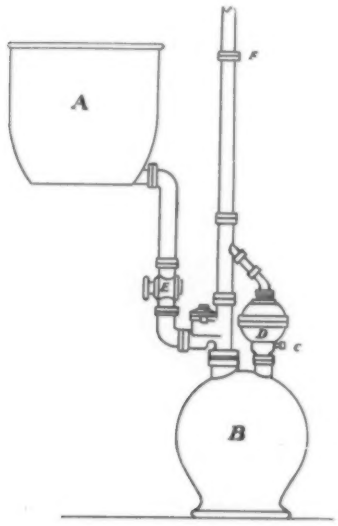
In the chemical and metallurgical arts special problems must be solved on account of the special properties of the materials and solutions to be handled. The manufacture of chemical stoneware apparatus—which in this country and abroad represents an industry the magnitude of which is perhaps not generally realized—is a special illustration of this necessity.

A problem with which this industry has been confronted for many years is that of lifting chemical solutions. Its importance is indicated by the large number of apparatus which have been devised and introduced into practice.

The Deutsche Steinzeugwaarenfabrik (German stoneware factory) für Canalisation and Chemische Industrie in Friedrichsfeld, which is one of the leading manufacturers of stoneware apparatus, has paid special attention to this problem for a long time, and has placed on the market at least some four or five essentially different designs, each representing a distinct improvement over the preceding one. Their latest apparatus, which is described below, is considered by the manufacturers to have reached the climax, and to fulfill all requirements of practice in a perfectly satisfactory manner; it has, therefore, been brought into commerce under the trade name "Friedrichsfelder Druckautomat Ideal."

Its main features are great simplicity of construction, due to the fact that a single ground sphere of stoneware is the whole regulating device; perfect safety and ease of operation, since the apparatus is almost proof against breakage, and the number of joints which might cause leakage is comparatively small; easy accessibility of all parts and perfect automatic operation without loss of compressed air or liquid if any accident should occur. The most important advantage of the new system, however, is that it needs no special adjustment depend-

ing upon the specific weight of the liquid. The apparatus may be used for liquids of any specific weight, and for lifting it to any height without requiring any changes. This means that if the apparatus has been used for lifting an acid of high specific gravity to a comparatively great height, it may be used immediately afterwards for lifting a lighter liquid to a much lesser height without changing anything in the apparatus.



APPARATUS FOR LIFTING SOLUTIONS BY COMPRESSED AIR.

The new apparatus may be used, for instance, to great advantage in connection with condensation towers, where it is necessary to repeatedly lift the dilute acid flowing off from the bottom of the tower up again to the top, in order to increase its concentration.

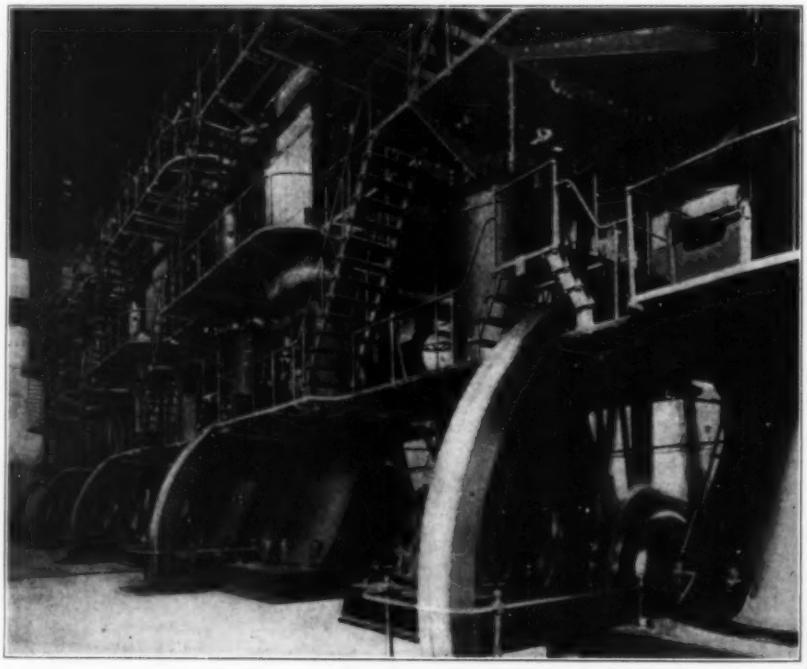
The construction of the lifting apparatus may be seen from the adjoining diagram. *A* is the reservoir containing the solution which is to be lifted. It passes through *E* and opens a valve at the junction of tube *E* and tube *F*, and enters into the vessel *B*, thereby driving the air from the vessel through a passage in *D* upwards into the tube *F*. The connection *C* to the compressed air reservoir is closed during this period. When the liquid reaches the top of *B* it acts automatically on a valve by which the passage is closed through which the air before escaped through *D* upwards, while simultaneously the connection *C* with the compressed air supply is opened. Compressed air now enters *B* and drives the liquid up through *F*, the valve at the junction of *E* and *F* being now automatically closed. The liquid is thus lifted upwards in pipe *F*, and this goes on until compressed air enters the pipe *F*. The valve in *D* then automatically reverses the two connections, shutting off the compressed air supply *C*, and permitting the air to escape from *B* through *D* upwards, while simultaneously the valve at the junction of *E* and *F* is opened again. New liquid enters now from *A* into *B* and so on. The apparatus is built at present in four sizes. The smallest size is able to lift up to 800 liters (about 210 gallons) per hour, the second size from 600 to 2,500 liters (160 to 660 gallons) per hour, the third size 2,000 to 5,000 liters (530 to 1,320 gallons) per hour, and the fourth size from 4,000 to 10,000 liters (1,000 to 2,600 gallons) per hour.

In cases where hot liquids are to be lifted, or under such conditions where a stronger pressure is required than is generally sufficient, the company advocates the use of corundum instead of stoneware. Corundum has a resistivity against pressure and tension about 30 per cent higher than stoneware, and is also much less effected by temperature changes. This application of corundum appears to be a new and very interesting development, although mention was already made of it in a paper by Dr. Hans Goldschmidt before the International Electrical Congress in St. Louis (our Vol. II., p. 405).

The quantity of compressed air which is required in any case may be found, together with its tension easily from the following rules. The quantity of compressed air equals the quantity of liquid to be lifted in one operation increased by about 8 per cent. The required tension of the compressed air equals the specific gravity of the liquid multiplied by the height of lifting plus 1/10 atmosphere for every 10 meters of height of lifting when referred to water. For instance, we may take the case of the third size of the lifting appartus, the contents of which is 180 liters of liquid. If the specific gravity of the liquid is 1.4, and if it is to be lifted 12 meters high, there will be required 180 plus 8 per cent = 195 liters of compressed air and a tension equal to $1.4 \times 12 + 1.4 \times 1.2 \times 0.1$, that is about 2 atmospheres. The apparatus is introduced in this country by Messrs. F. Bertuch & Co., New York City.

Blowing Engines.

In our report of the Bethlehem meeting of the American Institute of Mining Engineers, in our last issue, we mentioned the large blowing engines, installed in 1905 by the Allis-Chalmers Co., at the Hokendauqua plant of the Thomas Iron Co. Since they are an excellent illustration of the recent tendency of steel and iron prdoucers to install the most efficient and economical machinery available, a few additional notes on these blowing engines may be given here.



BLOWING ENGINES.

These blowing engines are of the well-known vertical steeple type, having steam cylinders 40 to 86 and both air cylinders 84 inches diameter, all with a stroke of 60 inches. This type was originated by Mr. Reynolds, of the Allis-Chalmers Co.,

many years ago, forming the original for the modern engines now in the market. In these blowers (as in the standard or long cross-head class of the Allis-Chalmers Co., the air cylinders or "tubs" are placed above the steam cylinders, and are each of the same size; *i. e.*, 7 foot-diameter by 5-foot stroke. The two cylinders thus have a free air capacity of 750 cubic feet per revolution.

Engines of this large size each weigh nearly a million pounds, and are almost always vertical, since the weight of their enormous working parts would produce great friction if of horizontal design. The comopund steam cylinders, when run in connection with a condenser, blow the air with the least expenditure of steam, and the heat thus saved is available for other purposes. There are now a large number of these engines in operation in the great iron and steel plants of the country.

The adjoining photograph shows a typical line of the steeple-compound blowing engines built by the Allis-Chalmers Co.

Notes.

American Electrochemical Society.—At the March meeting of the board of directors the following gentlemen were elected to membership: H. J. Williams, Philadelphia, Pa.; Henry Lacroix, Geneva, Switzerland; Samuel A. Tucker, Columbia University, New York City; Wm. H. Nichols, New York City. At the April meeting the names of the following gentlemen will come up for election: Ellis W. Bacon, Philadelphia, Pa.; J. L. Wills, Brooklyn, N. Y.; Edward E. Free, Ithaca, N. Y.; B. G. Klugh, Margnette, Mich.; Philip C. Walsh, Jr., Newark, N. J.

Journal of Explosive Industries.—Vol. I. No. 1, of the *Zeitschrift für das gesamte Schiess-und Sprengstoffwesen* has been issued on Jan. 1, 1906. Dr. Richard Escales, in Munich, is editor, J. F. Lehmann's Verlag, Paul Heyse Strasse 20, Munich, are the publishers. The journal is bi-monthly, and the subscription price for this country is 26 marks. The journal is intended to be international in the sense that articles will be published either in German or French or English. The first number contains, however, only articles in German.

Errata.—In Dr. Franz Meyer's article, published on pages 94 to 96 of our last issue, the following typographical errors should be corrected: Page 95, left-hand column, fourth paragraph, second line, read partition instead of partially; right-hand, seventh paragraph, first line, read Schmieder instead of Schurieder; page 96, fourth paragraph, eleventh line, read Cd instead of Co; thirteenth line, hence instead of these; fifth paragraph, fifth line, liquid instead of liquor.

Metallurgy and Electrometallurgy at Lehigh University.—Until 1898 the course in metallurgy at Lehigh University formed a part of the course leading to the degree of engineer of mines. Owing to increased demand and facilities for specialization, two separate courses were established in 1898, each of four years' length; one in mining leading to the degree of engineer of mines (E. M.) and the other in metallurgy, leading to the degree of metallurgical engineer (Met. E.). In 1902 a further step was made by establishing a separate course in electrometallurgy. There are thus two separate courses which are offered in the department of metallurgy, each of four years' length; one in metallurgical engineering, leading to the degree of metallurgical engineer (Met. E.) and the other in electrometallurgy, leading to the degree of electrometallurgist (El. Met.); both courses are under the direction of Prof. J. W. Richards. A full programme of the different courses is given in a recent pamphlet, entitled "Courses in Metallurgy," and published by Lehigh University, South Bethlehem, Pa.

Welding of Pipes by Thermit.—The Goldschmidt Thermit Co., of New York City, has recently issued an illustrated pamphlet giving instructions for welding wrought iron and steel pipes by utilizing the heat of the thermit reaction. The principles of the method of butt-welding pipes have repeatedly been described in our columns. The new pamphlet is specially interesting in its description of an improvement of the method, since instead of sheet iron molds, which have heretofore been used for that purpose, cast-iron molds have been substituted which considerably simplify the manipulation. The company has in stock the molds for the various sizes of standard wrought-iron pipes. This application of the thermit process has found considerable use in the welding of ammonia pipe lines on streets, as the welding can be done anywhere "in situ," while the perfect weld obtained in such cases by the thermit reaction always results in a very appreciable saving..

International Electrical Congress at St. Louis.—The total expenses of the International Electrical Congress at St. Louis in 1904 were $11,392.53, the total receipts from membership fees, sales of Transactions, etc., were $13,438.90. This excellent financial result was unexpected. As a matter of fact, an apparently inevitable deficit was turned into a credit balance by instituting at the right moment a canvass for the sale of copies of the Transactions. The executive committee of the Congress has now decided to offer the balance of $2,046.37 to the library of the American Institute of Electrical Engineers, as a fund in perpetuity commemorating the St. Louis Congress, the annual proceeds to be applied to the purchase of international electrical literature. Mr. W. D. Weaver was the resourceful treasurer of the Congress.

Refractories.—The high pressure at which metallurgical developments are now proceeding is indicated by the statistical figures for the consumption of refractories. The Harbison-Walker Refractories Co., in Pittsburg, reports that the orders received in February were 25 per cent larger in tonnage than those received in January, and nearly double the tonnage in September, 1905. This February's orders were the largest ever received in the history of the company during the past four years.

Testing Ores.—The Colorado Iron Works Co., of Denver, Col., has recently equipped its ore-testing plant with the most modern automatic machinery. The plant is of such a capacity that it is really an exceptionally well appointed mill, arranged in such a manner that tests can be carried out by any process, without handling the ore during any part of its course through the machinery, in exactly the same manner as it would be treated in a mill under actual service condition. These tests are carried out under the supervision of the experts of the staff of the Colorado Iron Works Co. An interesting illustrated description of this testing plant has recently been issued by the company in pamphlet form.

It is rumored that the **Automatic Refrigerating Co.**, of 22 Thames Street, New York, which company represents the merged interests of the Automatic Refrigerating Co., of Cleveland, Ohio, the Singer Automatic Ice Machine Co., of Bridgeport, Conn., and the Marshall Ice & Refrigerating Machine Co., of Boston, Mass. is about to remove their office, shop and refrigerating show plant to 630 Capitol Avenue, Hartford, Conn., where provision has been made for greatly increased manufacturing facilities. The Automatic Co. occupies a rather unique position in the refrigerating field in that it makes a specialty of small automatically-controlled equipment for which most of the 200 odd manufacturers of refrigerating and ice making machines do not care to bid.

Electric Furnace Process for Steel Making.— Mr. R. H. Wolff, 445 Broadway, New York, is the American representative of Dr. Paul Héroult for his electric smelting furnace and process. Mr. Wolff has been for many years a maker of high-grade steels and wires in this country, and was during the last five years the foreign representative of the Crucible Steel Co. of America. While the recent Sault Ste Marie experiments

of Dr. Héroult on the reduction of pig iron from ore in the electric furnace (see page 124 of this issue) are most interesting, and will undoubtedly attract much attention, it is to be expected that in this country the chief application of the Héroult furnace will be in connection with the manufacture of steel, where it has undoubted advantages, as was repeatedly pointed out in this journal. It is also to be expected that the Héroult electric mixer (see page 30 of our January issue) will prove a very valuable adjunct in steel mills with large output of staple products, like billets, rails, structural steel, etc., since for these purposes it will be possible to get with the electric process a superior and more uniform quality on a more economical basis than heretofore.

Gas Producers.—Loomis-Pettibone gas generating plants are attractively described by means of diagrams and colored plates in a new pamphlet of the Power & Mining Machinery Co., Milwaukee, Wis. This system gasifies bituminous coal, wood, charcoal, lignite, etc., and produces a gas that is particularly adapted to the operation of gas engines. The water-gas made by this system can be used separately in various feeding work, such as forging, welding, tempering, etc. This pamphlet can be had upon application to the company.

Fire-Brick.—We have received from the Kier Fire-Brick Co., of Pittsburg, Pa., their illustrated catalogue on Salina fire-brick. The analysis of Salina fire-clay is 43.750 per cent silica, 40.966 alumina, 0.769 sesquioxide of iron, 0.095 lime, a trace of magnesia, and 14.410 combined water. Velvetry, stock hole and bridge tile for heating, puddling and air furnaces are a specialty of this company. Velvetry tile takes the place of the old 9-inch arch in the neck of the furnace. Stock hole tile takes the place of arches over the doors. Bridge tile is so constructed as to prevent the bridge from splitting and making a 9 or 13-inch bridge. Besides useful general information, the catalogue contains a long series of dimensional diagrams of tiles and furnace blocks.

Giant Copper Matting Furnace.—The Dominion Copper Co., of Boundary Falls, B. C., has just placed an order with the Traylor Engineering Co., of New York for a giant copper matting furnace. The furnace will measure 48 inches x 204 inches inside the jackets at the tuyere line. The water jackets will be of steel, flanged and riveted, with no seams or rivets exposed to the fire. They will be arranged in two tiers, one above the other. The furnace will be entirely self-contained. It is one of the largest ever designed, and will have a capacity of 350 to 400 tons a day. The Traylor Engineering Co. will also furnish a large blower to go with the furnace.

Glass Industry.—A recent consular report from Germany refers to the process of a Belgian inventor, Mr. Fourcault, whose patent is stated to have been bought for $952,000 by the European syndicate of plate-glass manufacturers. "The new invention draws the molten substance from the pot and conducts it between rollers lying side by side. Seventeen pairs of these rollers are built up tower-like above the pot. The liquid mass cools on its way between the rows of rollers and comes out from them, polished on both sides, in any desired thickness (this being regulated by the relative position of the rollers), beautifully flattened and ready for use."

Concentration.—The North American Lead Co., Fredricktown, Mo., in making additions to its present plant, recently purchased five No. 3 Overstrom concentrating tables—two right and three left-hand—and fitted with copper riffles. These tables, which are built by the Allis-Chalmers Company, Milwaukee, were described and illustrated in our Vol. III., p. 218. In addition to the new concentrating machinery, the North American Co. has also added to its electrical equipment in the purchase of a 150-kw. "Bullock" type "H" direct-current generator, with small motors, types "H" and "B," aggregating a hundred horse-power. The electrical apparatus will be furnished by the Bullock works of the Allis-Chalmers Co., at Cincinnati.

Belt-Conveying Machinery.—We have received from the Robins Conveying Belt Co. a set of nine single pages, which by means of excellent illustrations facilitate greatly the understanding of the operation of belt-conveying machinery. The illustrations show typical applications of belt conveyors in actual practice in various metallurgical industries, and give a much better idea than a mere description could give. To mention only one example out of the whole series, Robins belt conveyors are very useful and economical as tailings stackers. In California, on gold dredges and at the large gold mines in the West and in South Africa, the Robins Conveying Belt Co. have installed a great number of their conveyors. This set of illustrated pages should go far towards getting almost as good an idea of the operation of belt conveyors in numerous cases as could otherwise be had only by inspection of plants in running order.

West Allis Shops of the Allis-Chalmers Co.—The progress of construction on the $3,000,000 extensions to the West Allis works of the Allis-Chalmers Co., in spite of delays of various kinds, is steadily being improved. Some idea of the unusual size of the new structure which will bring the total floor space for the entire plant to 1,513,000 square feet, may be gathered from the bill of material used in construction. Some of the largest individual orders ever placed by a Milwaukee concern have been given for material used in the building operations. Nineteen thousand barrels of Portland cement will be required for the concrete work, 785,000 feet of roof sheathing will help cover the works, and 850,000 feet of yellow pine and white oak will support the huge weight of structures and equipment. Even the scaffold lumber used only temporarily during construction will aggregate 10,800 pieces. Over 3½ acres of wire glass will be used in skylights and windows, while the weight of new equipment for the interior of machine shops will aggregate 3,080 tons.

Big Induction Motors for Anaconda.—Four of the largest induction motors ever installed in the West, and some of the largest in the country, with the exception of those installed at Niagara, will be used to furnish power at the $9,000,000 reduction plant of the Anaconda Copper Mining Co., in Anaconda, Mont. The Allis-Chalmers Co., of Milwaukee, will furnish this electrical equipment for the mammoth 8,000-ton concentrator and the Street Railway Company at Anaconda. The concentrator equipment will consist of four 1,200-hp. induction motors, three 300-kw. motor generator sets, together with the usual auxiliary accessories. This order is only one of many which will follow the determination of the Anaconda Co. to substitute Missouri River power, transmitted 90 miles at 70,000 volts, in place of the present power system installed in the largest smelter in the world. Each of the big induction motors will weigh over 40 tons, the weight of the entire equipment when ready for shipment being approximately 259 tons. The motors will be used in the concentration building, which is 600 feet long, through which a main line shaft extends the entire length. The motors will be rope-connected to this shaft and will carry the entire power load.

Oil Engines.—The largest order ever placed for oil engines has recently been awarded to the De La Vergne Machine Co., of New York, by the Baldwin Locomotive Works, of Philadelphia. This is for engines aggregating over 3,300 actual horse-power. Some of these are to be installed in Philadelphia, and the remainder at their steel works at Burnham, Pa. The installation will consist of 125 and 250-hp. Hornsby-Akroyd oil engines, and they are to be used for direct connection to electric generators and to air compressors, while others will be used for operating machine tools by belt. To characterize the efficiency of the Hornsby-Akroyd oil engine it is stated that with crude or fuel oil at 2 cents a gallon, the cost of operation is ¼ cent per actual horse-power-hour. The De La Vergne Machine Co. now holds the record of having sold the largest oil engine power plant, the largest ice plant and the largest oil engine power plant in the world.

Rock Crushing Machinery.—The Power & Mining Machinery Co., Milwaukee, Wis., have recently shipped a No. 9 McCully rock and ore breaker to the General Crushed Stone Co. for their plant at Rock Hill, Pa. This machine is to meet the most severe conditions of service ever before exacted of any rock and ore breaker—the crushing of the hardest known grade of trap rock. This No. 9 McCully will replace several machines of other make which were found unsuited for the arduous work imposed upon them. As a matter of fact, the material to be crushed is so hard that it practically ruined every machine heretofore used, through the breaking of the shafts, spiders, gearing, etc., as fast as new ones were put in. In addition to this No. 9 McCully breaker the Power & Mining Machinery Co. are also building for this same concern, for use in their plant at North Leroy, N. Y., a No. 10 McCully breaker, which is one of the two largest rock and ore breakers ever built, the first one having but recently been shipped to the Little Falls Stone Co., Little Falls, N. Y. In this connection attention may be called to catalogue No. 4 of the Power & Mining Machinery Co., since it deals with rock crushing machinery, and especially with the McCully gyratory rock crusher. The catalogue also contains illustrated notes on elevators, screens, hoists, etc., and sketches of complete crushing plants. In order to better handle their rapidly increasing business from the Rocky Mountain district, the Power & Mining Machinery Co. has opened an office at 312 Seventeenth Street, Denver, Col., which will be in charge of Henry F. Jurs, as district manager for Colorado, Wyoming and New Mexico.

Oxygen Generator.—The Roessler & Hasslacher Chemical Co. has now placed on the market an oxone generator of low-pressure type. It is a portable apparatus, for the instantaneous production of oxygen by means of oxone. The apparatus furnishes on an average 14 to 15 gallons of gas, and weighs, completely packed, about 8 pounds. The oxygen gas obtained is stated to be of 100 per cent purity. A circular recently issued by the Roessler & Hasslacher Chemical Co. describes the generator and gives instructions for its operation.

Engineering Publicity.—H. M. Baxter, engaged in engineering publicity with offices in the Lewis Block, Pittsburg, has recently added to his staff Chas. W. Brooke and Frank B. McConnell for the technical preparation and efficient distribution of catalogues, articles and advertisements for manufacturers of engineering practice. Mr. Brooke was formerly connected with the sales department of the Westinghouse Co., and Mr. McConnell was for a number of years engaged in illustration and catalogue work with the publicity department of the same company.

Asbestos for Wire Insulation.— Judge Archibald, of the Circuit Court of the United States for the middle district of Pennsylvania, has decided the infringement suit of Mr. Louis W. Downs *vs.* the Teter-Heany Developing Co., in favor of the defendant. The decision is that while the two processes of Downs and Heany have the same end in view—the insulation with asbestos of magnet wires—they are distinct and different and both may stand.

Wattmeter Suit.—The United States Circuit Court for the Northern District of New York, a few days ago, filed a decree enjoining the defendant in the case of the General Electric Co. *vs.* the Madison Gas & Electric Co., from using alternating-current integrating wattmeters or other motor devices embodying a provision for securing an approximate 90°-phase adjustment by induced circuit. The infringement, which formed the basis of this suit, was the using of Sheefer alternating-current integrating wattmeters, manufactured by the Diamond Meter Co., of Peoria, Ill. This is the same patent which E. B. Latham & Company, of New York City, dealers in Sheefer wattmeters, was enjoined on Nov. 4, 1905.

Concentrating Plant.—The Colorado Iron Works Co., of Denver, Col., recently entered an order for a 100-ton concentrating mill, complete erected, for the Mowry Mines Co., near Patagonia, Ariz. The equipment includes Colorado Iron Works standard rolls, impact screens, simplex tables, vanners, spitzkastens and settling cones. This company also reports the sale of impact screens to the Annie Laurie Mining Co., Kimberly, Utah; Mine La Motte Development Co., Missouri; the Bertha Mineral Co., Pulaski, Va.; the Hermosa Copper Co., Hanover, N. M., and bullion cars to the Great Western Ore Purchasing & Reduction Co., Keeler, Cal.

Thermometers.—Messrs. S. L. Baily, Jr., and F. Stuhl have organized the Philadelphia Thermometer Co., with offices at Arch and Ninth Streets, Philadelphia, Pa. The company will manufacture thermometers, pyrometers, barometers, hydrometers, hygrometers and chemical and physical glassware.

Electric Pyrometer.—We have received from Mr. Wm. H. Bristol two bulletins on the construction and applications of his thermoelectric pyromter, which was described on page 115 of our March issue. After April 1 the offices of Mr. Wm. H. Bristol will be at 45 Vesey Street, New York City.

Election.—At the recent annual meeting of the Wellman-Seaver-Morgan Co., of Cleveland, Ohio, the office of general manager, which has been vacant since the death last June of Mr. Charles H. Wellman, was filled by the election of Mr. S. H. Pitkin, whose present title will be first vice-president and general manager. Otherwise no changes were made in the officers of the company.

Sale of Massena Power Plant.—The Pittsburg Reduction Co. has taken over the St. Lawrence River Power Co., which owns the large water-power plant at Massena, N. Y. The Pittsburg Reduction Co. has already had for several years a large aluminium plant at Massena, and was the principal customer of the power plant.

Price List of Chemicals.—A valuable feature of the price list of Messrs. Charles Cooper & Co. is that not only the prices are given but also indications whether the prices are advancing or declining.

Bulletins.—The Allis-Chalmers Co. has recently issued the following publications: Bulletin 1,049, on Bullock railway generators for direct current; instruction book No. 5,003, on the installation and operation of Bullock direct-current motors and generators; instruction book No. 5,000, on setting and operating style D Gates rock and ore breakers; Bulletin No. 1,203, on Allis roller mills; Bulletin No. 1,702 on carriage feeds for saw-mills; Bulletin No. 1,705, on transfer machinery for saw-mills.

Calendars.—We have recently received several slightly belated calendars which are noteworthy in one or the other respect. The calendar of the F. J. Stokes Machine Co., in Philadelphia, is very neat, in green and white colors, and shows several illustrations of machinery and apparatus built by this company for th echemical and metallurgical industries. The calendar of the Laclede Fire-Brick Mfg. Co., of St. Louis, elaborates in greater detail the diabolic theme of last year's calendar of the same company, and is even more striking and more devilish.

Obituary.

Prof. R. Ogden Doremus.—With deep regret we note the death of Prof. R. Ogden Doremus, in New York City, at the age of 82. Member of old English and Dutch families of Manhattan Island, he graduated from New York University, and as early as 1848 had equipped a laboratory. He was one of the founders of the New York Medical College, the Long Island Hospital Medical College, and Bellevue Hospital Medical College, urging in each case the necessity of provisions of a chemical laboratory, where the students could have thorough chemical training. From 1853 to 1861 he was professor of natural history at the Free Academy, now the College of the

City of New York, and afterward was appointed to the chair of chemistry and physics in the same institution. He made the laboratory at Twenty-third Street and Lexington Avenue, a famous center for study, particularly in connection with electricity. His museum there was filled to overflowing with early electrical apparatus and instruments of great historical and technical value as bearing upon the early development of electrical industry. On one occasion, at the Academy of Music, in 1855, when lecturing, he took daguerreotypes of all the persons in the boxes by an arc light, and exhibited an induction coil with a 6-inch spark, a marvelous achievement in those days. His pioneer achievements in sanitation, toxicology, chemistry, etc., were not less notable. He was also a founder and president of the Philharmonic Society. One of his sons, Dr. Charles A. Doremus, is well known to our readers as a most distinguished leader in electrochemical developments.

Personal.

G. F. Brindley.—Our readers will be interested in learning that Mr. G. F. Brindley has resigned his position as works manager of the Niagara Electrochemical Co., and is going to Japan, where he will be associated with his brother, Mr. H. Brindley, who for several years has carried on a general engineering agency at Tokyo. Mr. G. F. Brindley has been intimately associated for many years with some of the most interesting of the electrochemical industries. He was born in Birmingham, Eng., in 1864, and in 1874 went with the rest of his family to Tokyo, where he was educated in the Imperial College of Engineering, taking his degree in engineering and chemistry. While at this institution he had the good fortune to study under such men as Milne, Alexander, Ayrton, Perry, Divers, etc. In 1883 he went to England, and then to California in 1886, but two years later returned to England, and there became associated with Mr. H. Y. Castner. As Mr. Castner's assistant Mr. Brindley worked on the manufacture of sodium by the distillation process, on the production of aluminium from the double chloride of aluminium and sodium, on the electrolytic production of sodium, on the manufacture of sodium peroxide, on the manufacture of cyanides on the electrolytic process for making caustic soda and chlorine, not to mention numerous other less important work done in Mr. Castner's laboratory. In 1896 Mr. Brindley came to this country, and became works manager of the Niagara Electrochemical Co., which manufactures sodium, sodium peroxide, etc., under the Castner patents. Within the last year Mr. Brindley has worked out successfully the difficult problem of producing fused sodium peroxide on a commercial scale, which has been put on the market under the name of "Oxone," and is used for generating oxygen by simple immersion in water. He has also been experimenting with Dr. R. von Foregger in an interesting research on the regeneration of air by means of sodium peroxide. Mr. Brindley is a charter member of the American Electrochemical Society, and was among the Niagara Falls delegation which attended the inaugural meeting in Philadelphia in 1902. His many friends here and in England will certainly join us in wishing him God speed and much success in his new enterprise.



G. F. BRINDLEY.

Digest of U. S. Patents.

Prior to July, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Production of Ozone and Miscellaneous Gas Reactions.

No. 87,155, Feb. 23, 1869, William Elmer, New York, N. Y.

Purifies, warms or cools and ozonizes air for use in dwellings. The apparatus comprises a purifier, in which the air passes over shelves wet with a mixture of lime-water and potassium permanganate, to remove carbon dioxide and oxidize impurities. In winter, it is then passed successively through an air heater, ozonizer and thermobattery connected to the ozonizer. In summer, the chemical solution is cooled by ice, and thereby cools the air. The cooled ozonized air passes over one set of junctions of the thermobattery, while the other junctions are heated by a gas flame. The ozonizer comprises a metallic sphere surrounded by a horizontal metallic ring, which has points extending toward the sphere. The apparatus, termed a "Climozonator," is said to consist substantially of "an ozonizer, a therma and a frigidarium," and to "produce a pure, genial and invigorating in-door climate at all seasons of the year."

No. 100,736, March 15, 1870, C. F. Dunderdale, New York, N. Y.

An ozonizer consisting of parallel plates or concentric tubes of glass, silvered or coated with foil on one side. The alternate plates constitute opposite electrodes. They are arranged in a box lined with glass, and having an inlet and outlet at opposite ends. The electrodes may be of metal spaced by glass pieces.

No. 109,601, Nov. 29, 1870, C. F. Dunderdale, New York, N. Y.

An improvement on the preceding, the electrodes being provided with fine projecting points of metal, opposed to the flat surface of the adjacent electrode, or to other points thereon.

No. 167,844, Sept. 21, 1875, Thomas W. Lion, Brentsville, Va.

Alleges a beneficial effect in the manufacture of illuminating gas by subjecting superheated steam and highly heated vapor of naphtha, after mixing, to the successive action of a voltaic cell and a thermoelectric battery. The voltaic cell comprises a wire-gauze basket, suitably insulated, containing table salt and provided with platinum conductors, the chamber around the battery being packed with "laminated" carbon or graphite. The generation of electricity is alleged to follow the contact of the hot vapors with the elements of this battery.

No. 186,207, Jan. 16, 1877, J. G. Hunt, New York, N. Y.

Steam and vapors of petroleum are treated for the production of illuminating or heating gas, by subjecting them to the action of a battery "of any suitable character." One terminal appears to be immersed in the petroleum tank and the other grounded.

No. 254,424, Feb. 28, 1882, T. J. Yost, Mahwah, N. J.

Portable ozonizing case comprising a battery, coil and ozonizer. The ozonizer comprises a gas tube, near one end of which is mounted a small fan driven by clockwork. The tube is externally wound with wire, constituting one terminal, the interior terminal comprising a centrally-supported metal rod, carrying a number of metal discs with serrated edges, the rod being covered with insulating material between the points of contact of the discs. A larger form of device is described for use in the ventilating systems.

